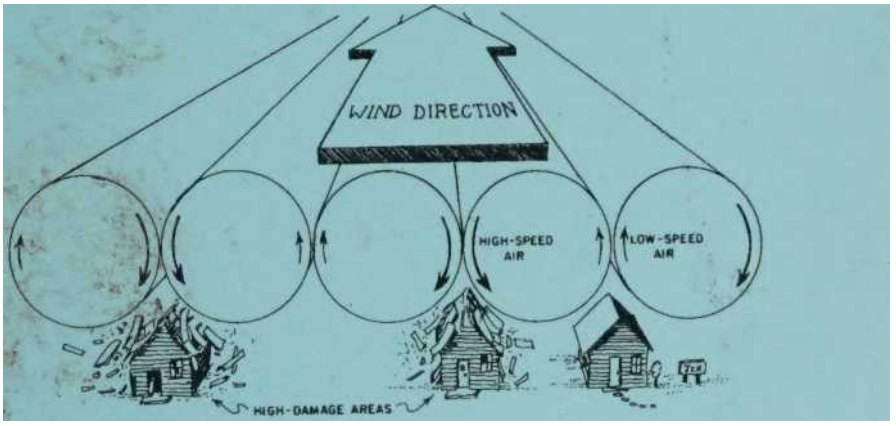
DARK DAYS, ICE FALLS, FIRESTORMS, AND RELATED

Compiled by

William R. Corliss



A CATALOG OF GEOPHYSICAL ANOMALIES

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Compiled by:

William R. Corliss

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CATALOGS:

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Tornados, Dark Days, Anomalous Precipitation (category GW) Earthquakes, Tides, Unidentifíed Sounds (categories GH, GQ, GS) Rare Hajos, Mirages, Anomalous Rainbows (category GE)

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Strange Universe (vols. Al and A2) Strange Planet (vols. El and E2)
Strange Life (vol. Bl)
Strange Minds (vol. Pl)

NEWSLKTTBR: Science Frontiers (bimonthly anomalv reports)

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William ***Sames***

Illustretions initialed JCH are Ihe work oí John C. Molden

PREFACE

Aíter inore luán twentv nine yoars oí scouring the seicntific and semiscientifie literal ure for anomalies, my major observador. that the searoh has boon most fruitful. In fací, 1 ha ve .vondcrrd why the scientifie community itselí has not buen systematieaily eompiling suoh Information. It is surprising that a Catalog uf Anomalies dúos not nlready oxist tu guide scientifie thinking and research. ll i.s al íeust as importan! tu rceognize vvhut is anomalous as it is to realizo what is well-explaineri in ternis oí prevailing paradigma. With this Outlook and pililo soplјy, herí is tho oighteenth volunte of suoh a Catalog. It is largeiy th.e pro duet of ono pcrson's library research. The work has boen Carried l'orward entirely througtl tho snle of {hese Catalog voluntes and nssooiatod publications.

Under the aegis oí íhe Soureobook P rojee t, I lia ve alreadv pubíished 34 volumes, totalling roughly 14.00U pagos ol source material on scientifie anomalies. (Seo pngt iv for a list ol titles.) As of this date, the.se 34 volumen represent onlv ubout 4(Vi, of my data base. New material is being added at the rate of about 1,200 new ítems per year, about 700 of whieh come from the current seicnt ifie literature. This aequisition rate eould easily he multiplied several- fold iust by spending more time in librarles. Kven after twenty-nine years. oniy a handful of Knglish-ianguoge journals have roecived ni y serious attontion. The journals in other languuges, government reports, confe renco papera, publieations of rv Searoh facilities, proceedings of State academies of Science. and an immense roservoir of pertinenl books remain almost untapped. L'very librar y lora y un eovers new anomalies; the worlü's librarles are bulgiug with tliem.

Given this rough assessment of the extent of the anomaly literature, one can understund why thi Catalog of Anomalies vvilJ require at least 30 volumen, matiy of theiri largor than the one vou now hoíd. 1 visualizo a shelf of these 30 voluntes, or an equivalent CD, aocompanied by nuister indexos. to be the logical ir.it i al step in providing seientists with acocss to what, in my opinión, is not weil-explained.
'! i c underlining of "my" is signifieant because anomalousness is citen in the oye oí the beholder. It dependa upon how weli one is satisíied with those explanntions based on currently acccptcd pnradigms. In the Catalog oí Anonali'es, th< data rulo; a!¡ theories and hypothesos ;ir». eonsidered tentativo. The history of science, from the luminiferous ether to the sintió continer.ts, demónstralos that this is « wi<*. polioy .

Wii: the Catalog of Anomaiies inipact Science sígnifienntly? Probablv not at lea si not righí away. Quite oí ten the initial reaction to the volumes olreadv pub- lished has been disbelief and oven disdain. l'hc data must he in error; tho data aro too oí'ten anécdota!; the data are too oíd; the purported anomaly was roallv explaim-d long ago. Cernís of truth reside in such complaints. So me science and somc observations reported in the Catalog are eertainly bad; but this is minien zed by a heavy reliance upon rcspccted journals. In addition, the baselinc oí well-cstablished theories--- against which anomalousness in measured--- is alwnys shiíting. And for evory anomaly that can be explainori away, a trip to a library will quíckly replace it with ten more from impeccablo sources. Nature is very anomalous or, equivalently, Nature is not yet well-understood. Mueh remains to be done in both anonmly research and in the resulting seicntific research that will ultimately dispose of these anomalies.

William H . Corliss

P.O. Box 107 Glen
Arm, MI) 21057
October 30, 2006

HOW THE CATALOG IS ORGANIZED

Purpose ot the Catalog

The Catalog oí Anomalies is designed to collect amí eategorize all phenomena that cannot be explained readily by prevailing scientific theories. Following its definition, eac-h recognized anomaly is rated in terms oí: (1) its substantiating data; and (2) the challenge the anomaly poses to Science. Next, all examples of the anomaly discovered so far are noted, some in detail. Finally, all examined references are listed. Thus, the Catalog is a descriptivo guide as vvell as a compendíum of examples and references. Scientific researchers there- fore have a ready-made foundation for beginning further investigations into these intriguing phenomena. This is the basie purpose of the Catalog: the collection and consohdation of the unknown and poorly explained to facilítate future research and explanation.

General Plan ot the Catalog

It was tempting to orgaruze this Catalog alphabetically, making it an "encyclopedia of anomalies." But many of the phenomena have obscuro ñames or, even worse, no ñames at all.
Under these circumstances, access to the data base would be difficult. Therefore, a System of classification was designed based upon readily recognized classes of phenomena and the means by which the observer detects them. Subject matter is íirst divided into nine general classes of scientific endeavor, as illustrated in the diagram. Few persons would have diffi- cultv classifying a phenomenon as biological, astronómica!, etc. The second, third, and fourth levels of classification are aiso based upon general))[1] recognized attributes, sueh as luminosity, sound, etc. The similarity oí this method of categorízation to those employed in natural history field guides is purely intentional. Like bird identification, phenomenon classification suon becomes second nature. In lact, almost all of the phenomena descríbed in the Catalog are accessible to everyone with five normal senses and perhaps binoculars and telescope.

Most cataiogs boast numbering Systems and this onc is no exception. Rather than employ a purely numerical System, the íirst three levels of classification are designaled with letters. The triplets of letters chosen have some mnemonic valué. Thus, a GWP anomaly is easily recognized as being in the geophysics class <G). weather-related (\V^{r}), and invulving some type of precipitation (P). The number added tu the tnplet of letters marks the fourthlevelof classification, so that CAVPl signifies cloudless rain. Every anomaly type has a unique alphanumeric codo, like GWP1. All cross references and indexes are based upon this System. Catalog additions and revisions are made much easier with this scheme.

The Catalog codes may seem cumbersome at íirst but their mnemonic valué to the eompiler has been signiíicant. Hopefully, they will help other users, too. The codes are simple, yet flexible enough to encompass the severa! thousand types of anomalies identified so far.

A glance through this volume of the Catalog will reveal that each example of a specific anomal) type bears an X-number, and each reference an R-number. GWP1-X12 therefore specifies the twelfth example of cloudless rain, and GWP1-R17 the seventeenth reference to cloudless rain. Indexes and cross references can consequently be made more precise then conven- tional page references.

How Dala and Anomalies Are Evaluated

Each anomaly type is rated twice on four-level scales for data "validity" and "anomalous- ness, " as defined below. These evaluations represent only the opinión of the eompiler and are really only rough guides.

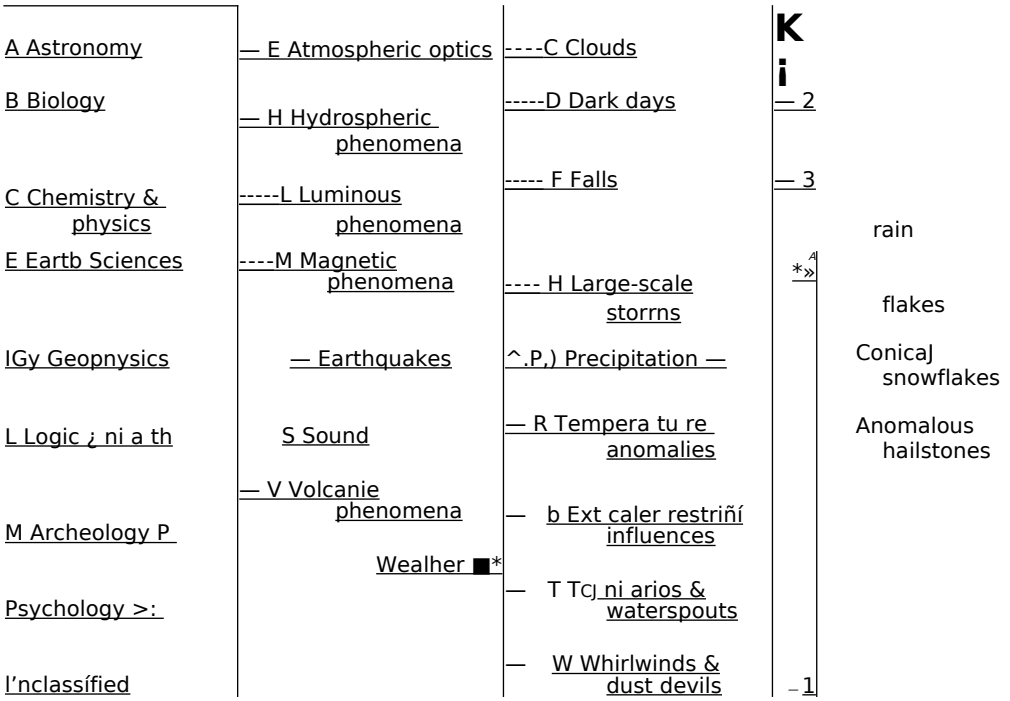
Data Evaluation Scale

1 Many bigh-quality observations. Almost certainly a real phenomenon.

2 Several good observations ur one or two high quality observations. Probably real.

3 Only a lew observations, some oí doubtful quality. Pheonomena validit) questionable.

4 Unacceptable, poor-quality data. Such phenomena are included only for purposes of comparison or amplifieation. Only two such ítems are registered in this volume.



Cataiog Codmq Scnema

Anomaly Evaluation Scale

1 Anomaly eanriot be explained by modifications oí preseni laws. Revolutionary.

2 Can probably be explained through relatively minor modifications oí present laws.

3 Can probably be explained using rurrent theories. Primarily oí curiosity valué.

4 VVell-explained. Included only fur purposes oí comparison and amplification. Only une sueh item is regislered in this volurne.

Anomalies thut rate "l" on both scales are very rare. Such anomalies, however. are the mosi important because of their potentia) for forcing scientific revo- lutions.

Anomaly Examples

Examples of anomaly types are designated by the letter X in the body of the Catalog, AJI ex- amples discovered so far are listed. Ií the example ís of the event type, time and place are speciíied if available. Some of the more significant geophysícal evepts, such as the remark- able "Dark Day" of 1780, may appear in severa! references, all of which are provided in full and keyed to the X-number of the example. Dark days are represented by scores of examples {hqndreds exist but have not yet been collected); but only a single example of dust spouts or T'land spouts" is listed. When library research has made many examples of an anomaly type available, several of the most interesting and instructive are reported in some detail. Direct quotations from the eye-witness accounts are frequently employed to convey accuraiely the characteristics of the phenomenon to the reader. These selected examples are printed fuil-width ín the Catalog columns. Examples of lees import are indented to sepárate them vlsually.

The Refetences and Sources

Each anomaly type and the examples of it are buttressed by all references that have been collected and examined. Since some references describe several examples, each reference iDcludes the X-numbers of the examples mentioned. When a reference eovers more thanone type of anomaly, it is repeated in the bibliography following each anomaly type. Actually, there is Jittle repetition of this sort in the Catalog.

Perusal of the Source Index wlll demónstrate that the great majority of references come from the scientific literature. Heavlly represented in this volume of the Catalog are: Nature, Science, Monthly Weather Review, Meteorological MagazLne, and the Quarterly Journal of the Roy al Meteorológica! Society. Several less technical publicatlons are also frequently mentioned: Marine Observer, Scientific American, and English Mechanic. The Marine Ob- server is a publication of the l). K. Meteorological Office. The English Mechanic was for many years an important English technical magazine, much like Scientific American. All of the seríais mentioned so far are considered generally reliadle, although one must always be wary. In addition to these often-referenced journals, there is a very wide selection of other publications. Some of these are more popular in character. In this context, it should be remembered that unusual phenomena do not seek out scíentísts, and the laymen who observe many anomalies have no knowledge of or access to scientific journals.

The time span covered by the sources ranges over 150 years. Many exeellent reports of anomalies come from the latter half of the Nineteenth Century. Although many scientists frown on such oíd reports, the quality is often good, and they should not be discarded arbitrarily. Not only were the observers of a century ago competent, they were unbiased by knowledge of modern theoxües and lived in an environment unpolluted by modern vehicles, effluxes, and other contaminants. It should also be mentioned here that the modern meteorological litera- ture tends heavily toward mathematical modelling and theory as opposed to eye-witness ac- couDts of strange phenomena. Two journals that are exceptions to this rule are the Marine Observer and the U. K. Journal of Meteorology.

The Indexes

This volume concludes with four sepárate indexes. At ñrst glance this may seem to be too much of a good thing. But in the context of a science-wide catalog of anomalous events and phenomena, these múltiple indexes have important roles to play,

The Subject Index ís essential to any work of this type. it is placed last for easy access. The Time-of-Event Index can be an important tool for anomaly re- searchers. It helps identify phenomena that are listed more than once because of theír divergent features, but which are really different aspects of the same event. This integrating feature will become more useful *as* Catalog volumes accumulate. To ¿llústrate, the 1908 Tunguska Event produced catalogable lumínous and barometric phenomena as well as atmospheric optical effects---all entered separately in different parta of the Catalog often in different volumes. It is possible that the Time-of-Event Indexes collectively will reveal cause-and-effect relationships that have not been recognized before.

The Source Index shows the dependence of the Catalog on scientific literature rather than newspapers and other popular publications. Its real purpose, though, is the rapid checkingto determine if a specific reference has or has not been caught already in the fishing nets of this Catalog project. The source Índex is doubly valuable because many foot- notes and bibliographies in the scientific literature display sources only; that is, titles and authors are omitted entirely. The researcher also comes across many vague references to such-and-such an article by so-and-so back in 1950 in Nature. The exhaustive and rather ponderous source and first-author indexes can help pin down many references lacking spe- cifics.

All four indexes use the catalog codes described above rather than page numbers. The codes are permanent whereas the page numbers will change as addenda and revised volumes are produced. The mnenonlc valué of the catalog codes is useful here, too, because the approxi- mate nature of each Índex entry is readily apparent, while page numbers give only location.

Each anomaly type and the examples of it are buttressed by all references that have been collected and examined. Since some references deal with several examples, each reference ineludes the X-numbers of the examples mentioned. When a reference covers more than one type of anomaly, it is repeated in each anomaly bibliography. Actually, there is little repetition of this sort in the Catalog.

Catalog Addenda and Revisions

Over 1200 new reports of anoinalies are collected each year from current and older scientific journals. New anomaly types and additional examples of types already cataloged are accumulating rapidly. When sufficient new material has been assembled, Catalog volumes will be revised and expended.

The Sourcebook Project welcomes reports of scientific anomalies not already re- gistered in extnnt Catalog volumes. Reports from scientific journals are prefer- red, but evcrything is grist for the anomaly mili! Credit will be given to submit- ters in new and revised Catalog volumes. If the reports are from current litera- ture, they may be mentioned in Science Frontiers, the Project's newsletter. Send data to: Sourcebook Project, P.O. Box 107, Glen Arm, MD 21057, USA.

INTRODUCTION TO WEATHER PHENOMENA

"Weather" is a composite experience of sight, sound, temperature, and other sensations of the elementa. The phenomena of this Catalog volume are not primarily luminous or acou- stic or confined to the sensor}' chaimels that form the bases for the other volumes ín the field of geophysics. Here, we deal with rain, fog, wind, clouds, precipitation, and sun- shine but only when they are anomalous or at least curious enough to attract our attention.

Our weather experiences are so widely variable that a phenomenon has to be very strange indeed to gain access to this volume. The entrance criteria are not so much related to in- tensity or rarity as they are to unexpectedness and their deviations from meteorológica! theory. Thus, very heavy general rains, even with catastrophic flooding, are excluded, while rain from a cloudless sky and "point" rainfall are welcome additions.

Several themes that thread their ways through the geophysical volumes of the Catalog recur in this book:

1. The importance of electricity ín geophysical phenomena
2. The possible influences of the sun, moon, planets, and inbound meteoric material on terrestrial weather
3. The occasional prankish, frívolous behavior of some weather phenomena. This judg- ment is, of course, highly subjective.

One interesting feature of weather phenomena taken as a whole is their rather low level of anomalousness; at least when compared to other geophysical phenomena in the Catalog of Anomalies. Weather, it seems, is not as strange as, say, luminous geophysical phenomena. There are more plausible theories available to explain weather phenomena than for ball light- ning or long-delayed radio echoes. Of course, this does not mean that scíence understands all facets of the weather----------this volume would not exist if it did.

GWC UNUSUAL CLOUDS

Key to Phenomena

GWCO Introduction
GWC1 The “White Sky” Phenomenon and Low Altitude Haze
GWC2 Cloud Arches
GWC3 Polar Bands
GWC4 Miniature Thunderclouds
GWC5 Noisy Clouds
GWC6 Noctilucent Clouds
GWC7 Ring Clouds
GWC8 Thunderclouds Affecting the lonosphere
GWC9 Circular Holes in Cloud Decks
GWC10 Anomalous Cloud Lines and “Streets”
GWC11 Dispersal of Clouds by the Moon
GWC12 The Morning Glory Phenomenon
GWC13 Long, Hollow, Cylindrical Clouds
GWC14 Cloud Spokes Radiating from Thunderclouds
GWC15 Great Excess of Ice Crystals in Cumulous Clouds
GWC16 Cloud Brightness Changes
GWC17 Anomalous High-Altitude Haze Layers
GWC18 Anomalously Long and High Arctic Cloud Plumes
GWC19 Atmospheric Rivers and Reservoirs
GWC20 Black Spots on Ultraviolet Images of the Earth’s Dayglow
GWC21 Bizarre Clouds
GWC22 The Mystery Cloud of April 9,1984
GWC23 Green Clouds
GWC24 Exotic-Chemical Clouds
GWC25 Layers of Unidentified Material, Not of Natural Origin, in the High Atmosphere
GWC26 Artificial Polarity-lnversion of Thunderclouds
GWC27 Cloudiness Correlated with Cosmic-Ray Intensity
GWC28 A Curious Ribbon Cloud

GWCO Introduction

Clouds can be classified as unusual if they possess anomalous shape, motion, color, orien- tation, or emit unaccountable light or noise. Meteorologista recognize a variety of clouds as "usual” even though they are not fully understood. Lenticular clouds, for example, are lens-shaped and produce not a few UFO reports. Nevertheless, lenticular clouds are a recognized species and at least partially comprehended. They are, therefore, omittedhere. Rotating, ring-shaped clouds and some spectacular roll clouds <i.e. , the Morning Glory) do find places in this Catalog. Although these types of clouds are doubtless created by atino- spheric vórtices and solitary waves, they are neither common ñor easy-to-explain. Cloud arches connecting two seemingly unrelaied clouds pose some intriguing questions: Are the arches umbilical in charaeter? Is a flow of electricity involved ? Some clouds seem to in- teract in mysterious ways with the earth's magnetic field, as in the case of the so-called polar bands, which are evidently cirrus clouds aligned with the magnetic meridian. How can the earth's magnetic field twist lines of nonmagnetic ice crystals into neat bands orien- ted like compass needles ? All in all, there are many imponderables in the charaeter and behavior of the prosaic cloud.

GWC1 The “White Sky” Phenomenon and Low-

Description. Persistent veiling of the sky over wide areas by a high layer of haze of un- certain origin. During periods of white sky, the dimmed sun appears white and can be view- ed with the naked eye, Stars are seen only dimly at night.

Background. The most notable examples of "white sky" oecured in Europe during the sum- mers of 1912 and 1916. The superficially similar Arctic hazes are recent, being due mainly to industrial pollution.

Data Evaluation. The European 1912/1916 episodes and the recurríng Arctic low-altitude haze are well-established in the Science literature. Rating; 1.

Anomaly Evaluation. Several reasonable explanations are noted below, resulting in a low anomaly rating. Rating: 3.

Possible Explanations. Dust raised by violent winds in desert areas; volcanic eruptions, industrial air pollution. A eomet's tail was suggested for the 1912 episode.

Similar and Related Phenomena. Stratospheric haze layers (GVVC17); high-level "auroral" hazes (GLA12 in Remarkable Luminous Phenomena); noctilucent clouds (GWC7); dry fogs and dust fogs (GWD4).

Examples of White Sky

XI. Summer 1912. Much of the Northern Hemisphere, especially Europe. ''For weeks, when not clouded, it (the sky) has been white, and one could look at the white sun with the naked eye near the zeníth in the unclouded sky-----not a patch of blue to be seen, and frequently no clouds. (Rl) Al so seen in France and Germany.(R2) "It having been my good fortune to spend a few weeks in Ireland lately, I have been able to observe the strange condition of the upper atmosphere, which has been noted by several of our correspondents. At Ealing the sky has been of unusual whiteness, certain- ly, since the míddle of June. This haze be- came more marked in August, and when I went to Western Ireland, on the 15th of that month, I found it much denser. During the daytlme the sun never shone brilliantly, and towards sunset the upper atmosphere was filled with layers of fleecy mist. (R3). Ex- traordinary twilight colors seen in Europe. (R4) White sky also observad by a Green-land expedition, even when above 8,000 feet altitude. Dust from the eruption of Katmai in Alaska a possible cause. (R5)

Additíonal details on the 1912 "white sky" appeared in the following lptter from W.N. Shaw then working at the British Meteorological Office. "During the past rnonths several cor respondents have written to the Metero-logical Office drawing attention to the peculiar persistent whitish haze which has covered the sky even on apparently cloudless days during the past summer. On August 11, Sir John Moore wrote from Dublin remarking-------'the sky is constant-ly covered with a thin film of apparently uniform cloud in which no hules develop, and through which the sun. moon, and stars shinr with a subdued, siokly brightness.' Very similar dése ríptions have come to hand from Mr. Henry John-stone, writing on August 13 from Down- patrick, and from Rev. F. Hamilton Clay- pole Rectory, Newark.

"The phenomenon seems to have pre- vailed over a very wide nrea, for in the July, August, and September numbers of the Meteorologische Zeitshrift similor observations are reported from such places so far apart as Heidelberg (Pro-fessor Max Wolf), Switzerland (Professor Maurer), and Sweden (Professor Hildel- brandsson).

"A long account has also reached the Office from a correspondent in Riga. Mr. VV.D. Addison writes----------'We have had a magnificent, warm, dry summer, with long spells of cloudless weather, but since the latter part of May, never once have we beheld a sky which ít would be reasonable to cali blue. A 'veil'—I can cali it by no other ñame—seems to have

been imposed between us and the sky.
The sun presente a most unusual appear- ance, very difficult to describe; it has a dead appearance, and frequently 1 have been able, two hours or more be- fore its setting-time, to look at it with nnprotected eyes without blinking. It then presents a sickly, almost green, and pallid appearance; it aiso entirely fails to light up the eloud formations." (H7)

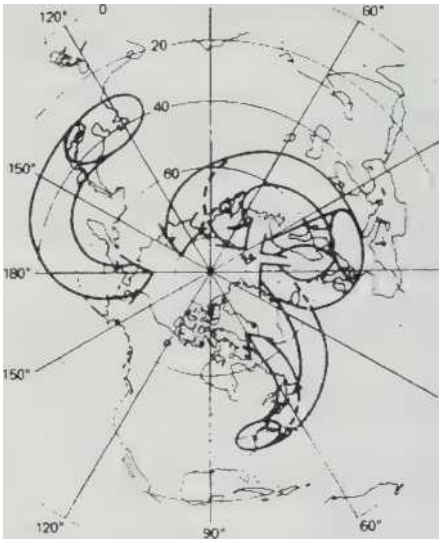
X2. Frequent occurrence in March and April. Alaska and part oí Aretic Ocean.
"It's quite a high haze, around 10,000 feet. You can still see the mountains off in the distance. Yet the sky has a whitish, díf- fuse look to it... (from the air) the horizon almost becomes invisible... One oí its puz- zling features is its height;.. .haze usually hugs the ground... It no doubt also goes over at least part oí the Aretic Ocean." Possibly due to dust from the Gobi and other Asia deserts. A layer of haze at lower levels seem to be air pollution from Japan. (R6)

The expanding and thickening Aretic haze has been sampled by HOAA aircreft flights through it in 1983. " R.A. Ras- mussen of the Oregon Gradúate Center, Beaverton, Ore., said the haze was ex- ceedingly thick just over the ice cap, reaching as high as 5450 m, but thinning at higher altitudes. Air samples taken by Rasmussen on the flight have indicated so far, that the haze was composed largely of perchloroethylene (PCE).
Among other things, the Chemical PCF is found in dry cleaning solution and hydro- carbons from burning fossil fu el.

"Evidence such as this supports the belief that the haze is caused by human activities. According to James T. Peter- son, Director of NOAA's Geophysical Monitoring for Climatie Change in Boul- der, Colo., much of the haze is thought to origínate from Europe and Northern Asia." (R12)

X3. Summer 1916. Europe. The "white sky" of 1912 was repeated over the European continent, perhaps elsewhere, too, although no other reports are on file. In 1916, however, the phenomenon was ascribed to "deterioration of the atmosphere," which again tells us nothing about its cause.

Dr. Maurer, director of the Swiss Meteorological Institute wrote the follow- ing about the 1916 occurrence.



Naval Research Review

Possibte sources and transport routes for airborne pollutants al Aretic mid- altituües. (R14)

"Remarkable optical deterioration of the atmosphere became apparent in the Swiss Alps during the last ten days of July by the persistently abnortnal magni- tude and unusual intensity of the bright patch round the sun, to which the ñame aureole is sometimes assigned. Observa- tions in previous years have established a well-defined mínimum during the summer months, both in the diameter and the intensity of the solar aureole, but during the present year, from Juiy 23 to the middle of August, the diameter generally obtained 120° to 130°, and on August 25 even 140°, with relative great intensity." (R9)

X4. 1883-4 and 1902-3. "White sky" phenomena similar to those of XI (1912) and X3 (1916) are also on record. (R9)

X5. June 1950, Pacific Ocean. "A strange haze covering a million square miles hung over the Pacific today for the third straight day. Official obser- vers said it contained no atomic radia- tion.

"I he írnze extended westward beyond Wake Islond, 2,000 miles away, and 400 miles eastward Its north-south range was about 600 miles, with Johnson Island

on the Southern edge.

"While the source of the grey foglike mist had not been determined, the best surmise of the Weather Bureau here [Honolulú] was that ít resulted from foreign matter, including a heavy con- centration of salt particles, trapped beneath a layer of immobile air at 6,000 feet.

"It is expected to remain until sur- face winds return to blow it away.

"Whatever the source of the mid- Pacific phenomenon, lt has no parallel in Hawaiian weather records.

"R.H. Simpson, in charge of the Honolulú Weather Bureau, described the fog as composed mostly of salt particles swept up in spray from the ocean." (RIO) Note that this mid-Pacific haze seems to have a different source and different characteristics from the recurring low- altitude Arctic haze. <X2)

References

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GWC2 Cloud Arches

Description. Narrow bands of clouds Crossing the sky in an are that usuaJly joins two widely separaied cumulus clouds. While most arches seem formed from cloud, the arch sometimes seems to be simply a band of light. Most observations of cloud arches have been made from ships at sea.

Data Evaluation. A well-attested phenomenon. Rating: 1.

Anomaly Evaluation. The nature of the cloud arch is in question. Is it simply a cloud formed from a long, narrow vortex, or possibly of electrical origin similar to that suggested by some for tornados, or purely an optical phenomenon? No matter which, the formation and maintenance of these arches are very puzzling. Rating: 2.

Possible Explanations. Cloud arches may be long, narrow roll clouds that fiare out into cumulus clouds at both ends----------something like an íntercloud tornado funnel.

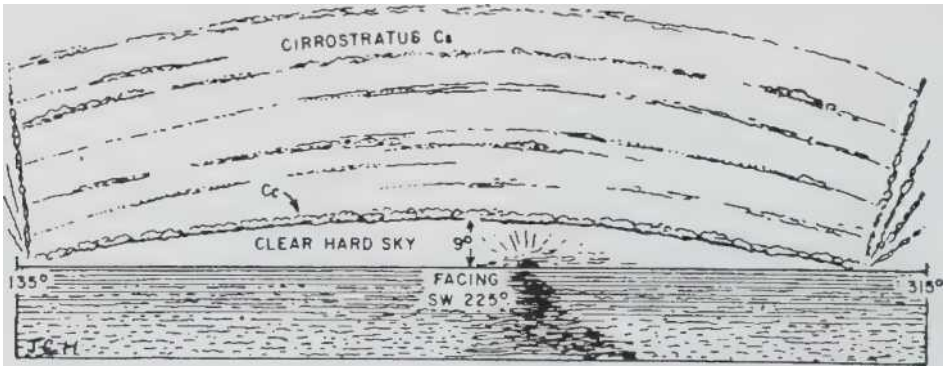
Similar and Related Phenomena. Roll clouds (GWC12); anomalous cloud lines (GVVC10); magnetically aligned cirrus clouds (GWC3); mirror-type cloud mirages (GEM); and, in geom- etry if not reality, cloud-like auroral arches (GLA2) and the banded sky phenomenon (GLA23); waterspouts between clouds fGWTIO).

Examples of Cloud Arches

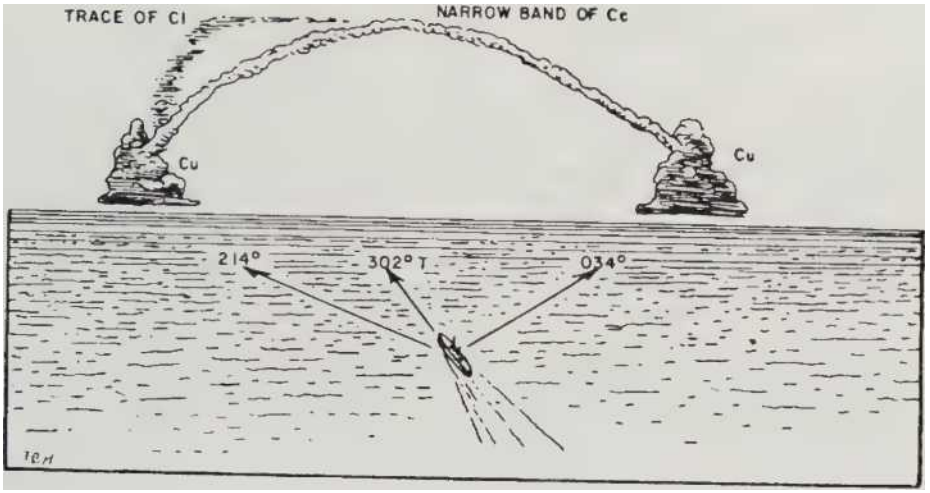
XI. February 8, 1933. South Atlantic Ocean. A well-defined arch of cirro- stratus joins two rain squalls about 8 miles apart. (R1)

X2. November 24, 1933. South Atlantic Ocean. "From two polnts on the horizon bearing 138° and 304° respectively, anarea of hard clear sky arched itself to an altitude of 9°. This máximum angular height was approximately above the sun, which set bearing 237 1/2°. Maintaining an almost equal distance with the rim of this arch was another smaller arch with an angular height of 2°. The space between these two arches was packed with Cirro-Cumulus globules which appeared to be closely stowed between well-defined layers of Cirro-Stratus clouds. Another patch of Cirro-Stratus cloud, low in the sky, temporarily dimmed the setting sun. From the two points on the horizon, bands of cloud radiated and passed obliquely into the sky, the Northerly band in both cases being composed of Cirro-Cumulus clouds. These bands became fainter with altitude and finally diffused into the upper sky. "
(R2) This ex ampie resembles in some ways the displays of aligned cirrus clouds (GWC3).

X3. May 31, 1952. Indian Ocean. "Two very dark towering Cu clouds bearing 034°, appeared to be joined to a single dark towering Cu cloud, bearing 214°, by a narrow bandof



System of cloud arches in the South Atlantic (X2)



Cloud arch connecting two cumulus clouds (X3)

Ce which stretehed across the sky over the ship. This formation lasted about 2 hours before disintegrating. The moon was not visible at the time and the sky was cloudless cxcept for the above formation." (R3)

X4. June 3, 1952. Indian Ocean. A cloud formation similar to that of X3. (R3)

X5. April 25, 1956. Arabian Sea. "A thin whitt band, not appeared to be cloud, joined two lufts of towering Cu. The band remained as such untíl the clouds dispersad, " (R4)

X6. July 12, 1980. Strait of Gibraltar. ᴹAt 1825 GMT whilst the vessel was transiting the Strait of Gibraltar, a line of low cloud was observed Ln an otherwise cloudless sky, see sketch, The cloud was in the form of an arch in an east-west line, reaching the surface approximately 2 n. mile ahead and astem of the vessel. Visibility under the cloud was about 10 n. mile in the north-south direction and 2 n. mile to the eastand west. Once the vessel reached the point where the cloud touched the surface, the visibility was reduced to approximately 1.5 n. mile. Whilst the vessel was passing the cloud, the barograph trace fell almost ver- tically and both the air and sea tempera- tures dropped several degrees. " (R5) Al- though there are no cumulus clouds at the terminations of the arch, this phenomenon is very similar to others in this category.

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R3. Townshend, C.R.; "Unusual Cloud Formations," Marine Observer, 23:76, 1953. <X3, X4j
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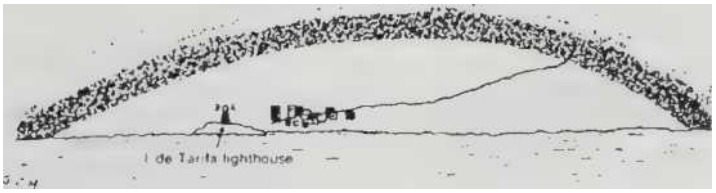


Curious cloud arch In the Strait of Gibraltar. The ends terminated in the ocean at points 4

GWC3 Polar Bands

Description. Long, parallel, sharply defined streaks of cirrus cloud aligned along the mag- netic meridían. Taking perspective into account, a ground observer sees these parallel clouds as fans radiating from points on the northern and Southern horizons. They spread out when overhead into evenly spaced bands, tenuous in nature, more like stríps of haze in some cases, and sometimes faintly lumínous at night.

Background. Von Humboldt applied the term "polar bands" to these geometrically aligned cirrus bands. English folklore dubs them "wind reels. " Early observers believed that this phenomenon was surely associated with auroral aetivity. Indeed, many of the examples presented here possess auroral overtones. See GLA12 in this regard. The polar bands also bear a striking resemblance to the banded sky (GLA23), and in fact may be the same phenomenon, occurring in the daytime instead of at night.

Data Evaluation. Many observatíons of polar bands reside in the older literature, but they are recorded infrequently in recent times. Rating: 1.

Anomaly Evaluation. Two characteristics of the polar bands make them anomalous: (I)Their frequent alignment with the magnetic meridian; and (2) A less frequent association with auroral displays. Cirrus clouds would not seem to have intrinsic magnetic properties, ñor do they occur anywhere cióse to the altitudes of normal auroras. Rating: 2.

Possible Explanations. The magnetic alignment may be just a coincidence, perhaps due to the creation of cirrus bands by high altitude winds with preferred directions of propagation. Less likely is the possibility that the auroras, which are usually magnetically oriented, and polar bands have a common cause, say, partióles that cause high-altitude luminous pheno- mena and low-altitude nucleation of ice crystals.

Similar and Related Phenomena. Banded skies (GLA23), and the apparent cióse relationship between some auroras and some clouds (GLA12), cloud arches (GWC2),

Examples of Polar Bands

XI. October 30, 1870. England. "On that day the finest films of cirrus stratus cloud radiated in a most beautiful and symmetri- cal manner from a point below the north- west horízon, and their resemblance tothe streamers of aurora was most perfeet. Later, at about 1 o'clock on the same day, long ridges of cumuli were arranged in the same manner. " {R1)

X2. April 8 and 9, 1871. England. Long streaks of cirrus stratus were polarized NW-SE. Auroral streamers on April 9 were parallel to the cloud display. (R2) X3. April 10, 1872. Champion Hill, England. Cirrus clouds radiated from magnetic north. An aurora followed. (R3) X4. June 18, 1872. England. Masses of cirrus cumulus clouds were polarized nearly along the magnetic meridian. <R4) X5. October 23, 1872. England. Polarized streaks of haze and cirrus clouds. (R5) XC. September 21 and 12, 1873. England. Polarized streaks of haze and cirrus clouds. (R5)

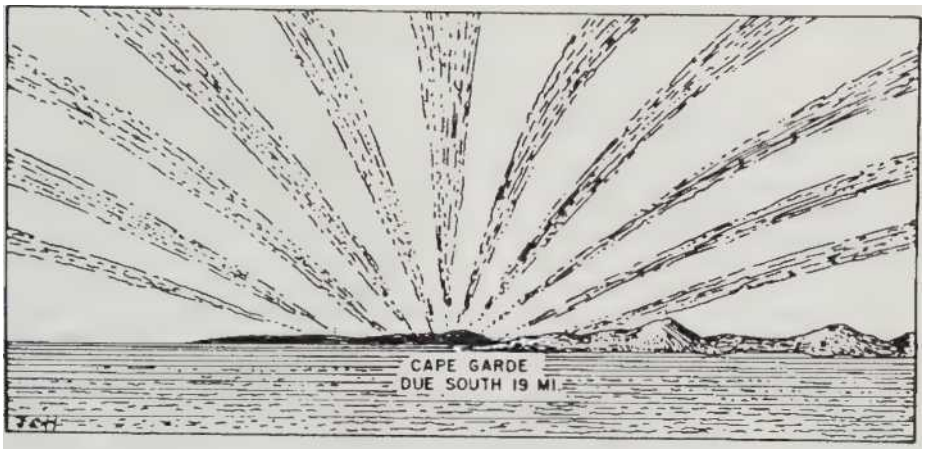
X7. March 12, 1900. Harefield, England.

"A number of gauze-like white clouds, in perfectly straight lines, radiated like ahuge fan from a point due north, slightly below the visible horizon, where a clump of elm trees, about half a mile away, grew. The clouds were straight white streaks, of which the edges shaded off into the blue of the sky visible between them. The streaks were at regular dístances apart, and about 24 in number above the horizon, those near it being but a few degrees from the horizontal, and stretching from the centre to about 40° of declination; but those near the horizon, apparently about 60°, and what struck me as most singular, they all ended almost abruptly." Later, the clouds extended and converged in the Southwest. (R6)

X8. June 30, 1925. East London, South Africa. Cloud streamers radiated from the South. (R7)

X9. January 25, 1926. Indian Oeean. Cirrus streaks radiated from a point bearing 45°. (R8) A rare ínstance where the streaks do not radíate from magnetic north. (WRC)

X10. October 22, 1927. MediterraneanSea.



Polar bands over the Mediterranean (X10)

"On 22nd October, 1927, off Cape Garde at about 5.30 a. m., observed remarkable cloud formation consisting of radiating streaks of Cirrus cloud forming complete evenly spaced ares terminating in approxi- mately the true north and South pomts of the horizon. It gave the sky a wonderful domed appearance and lasted until after sun- rise (about 6.45 a. m.), the formation gra- dually broke up mergíng into Alto Stratus. " (R9)

XII. General observation. A study of cirrus bands observed 1840-1847 indicated that their alignment was most frequently along the magnetic meridian. (RIO) Contrast thls with X12. (WRC)

X12. General observation. Polar bands are no longer believed to be preferentially aligned along the magnetic meridian. (RII) X13. March 20, 1932. Oxford, England.

Just before sunrise, a single band of cirrus 5° wide spanned the heavens north to south. It was a brilliant pink. (X12) If the observer had not identified this arch as composed of cirrus cloud, it might well be classified as auroral in eategory GLA2, auroral arches. (WRC)

X14. July 24, 1933. Westcliff-on-Sea, England. "During the evening of July 24th, 1933, an unusual cloud formation of cirrus was seen at Westcliff-on-Sea, Essex. At 21 h. 20 m. G. M. T. a belt of cirrus cloud was observed stretching across the western sky at an elevation of 35°, from north to south, forming a bow, and moving in an easterly direction. This was'rapidly followed by a second belt, and between 21 h. 20 m. to 21 h. 50 m. eight belts of cloud travelled across the sky from due west to east, the eighth belt disappearing at 21 h. 50 m. at an elevation of 105°. None of the belts ap- peared from the west until at an elevation of 35°, probably because the western sky was too bright at the time to allow any contrast at lower elevations, ñor were any visible after reaching the elevation at 105°. At 21 h. 30 m. four belts were visible simultane- ously at elevations of 35°, 55°, 70° and 105° from west. All the belts were approxi- mately 1 1/2° ín width, the width being even throughout their length. The belts of cloud were whitish in appearance, the three lower being very clear, whilst that which had pas- sed overhead was considerably less clear. The brilliancy of the belts was similar to that of the Milky Way on a clear moonless night. As the belts of cloud travelled across the sky they presented a striking appearance. As each attained the 70° elevation and be- yond, stars ín the path of travel were plainly seen through the cloud, which clearly denotes that the cloud belts were very tenu- ous." (R13) Once again the re is little to sepárate this observation and the banded ski' phenomenon (GLA23). (WRC)

X15. General observation. Cirrus clouds olten align in bands par all d to the magnetic meridian. This orientation rnay br due to ice crystais forming around meteoric dust particles which are fre- quenlh magnetic. (Rll* See also X16. X1G. General obsematmn. In reference to X15, **meteoric** dust has not been proven to be a nucleating agent fe r Lc< crystais. Purthermore, the alignment of individual ice crystais would nut explain the macro-

scopic structure of the polar bands; i. e., parallel streaks aligned with magnetic north. (R15)

X17. November 24, 1883. Corinth, Mis- sissippi. T.E. Whitfield, the Chief Sig- nal Offícer at this location, reported polar-aligned cloud bands. "The pheno- raenon was observed at 7 p.m., when twelve well-defined bands of dark clouds were seen diverging from a point beneath the 'north* star. Four of these bands were east of the star named, and the remaining eight were west of it, those near tho western limit of the display being shorter and less inelined toward the horizon. The lower ends of the seven largest clouds terminated abruptly at an equal distance from a coromon point near the northern horizon, leaving an almost perfect semicircle of clear sky beneath, from which the bands radiated like the spokes of a wheel."

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R2. Birt, W.R.; "Polarisation of Clouds and Magnetic Phenomena," English Mechanic, 13:131, 1871. (X2)

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R5. Ingall, Herbert; "Polarisation of Haze, " English Mechanic, 18:262, 1873. (X5,X6) R6. Sigma, Jemina; "Beautiful Atmospheric Display, " English Mechanic, 71:127, 1900. <X7)

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R8. McCornish, A. B.; "Radiating Streaks of Cirrus,” Marine Observer, 4:5, 1927. <X9)

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R13. Horrex, E. J.; "Luminous Night Cloud," Meteorological Magazine. 68: 186, 1933. (X14)

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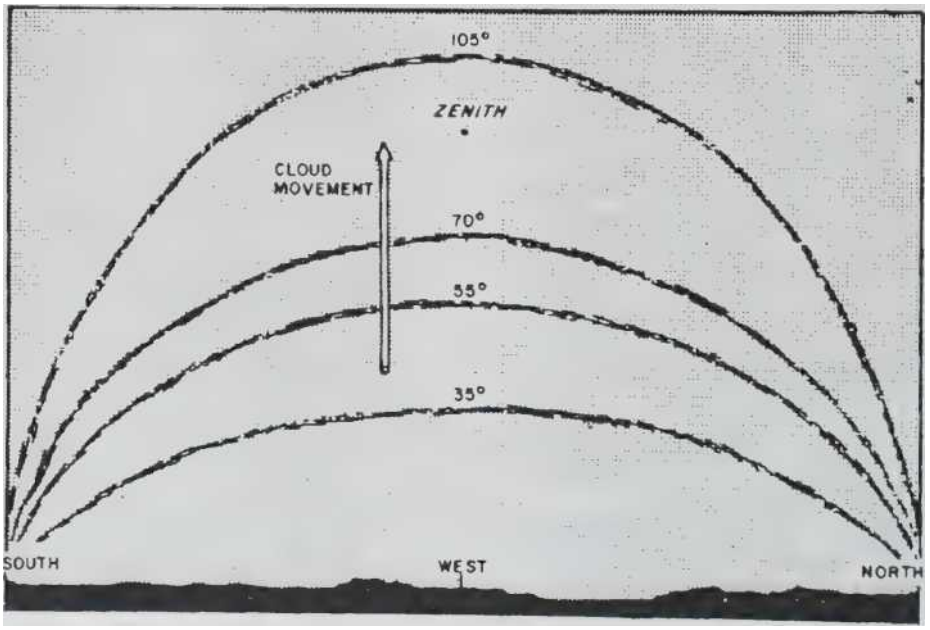

North-soulh cirrus streaks over England, 1933 (X14)

Nature, 199:900, 1963. (X15)
R15. McDonald, J.E,, and Kellner, L.; "Meridional Alignment of Tropical Cir- rus Clouds," Nature, 201:1316, 1964. (X16)
R16. Anonymous; Monthly Weather Re- view, 11:264, 1883. (X17)

GWC4 Miniature Thunderclouds

Description. Electrically active thunderclouds with dimensions measured in feet rather than miles.
Data Evaluatlon. Only a single good observation, and this under special meteorological conditions. Rating: 3.
Anomaly Evaluation. Normal thunderstorm convection cells are measured in thousands of feet. It seems improbable that a cell a few feet across could form under natural conditions. Rating: 2.
Possible Explanations. The local conditions (XI below) tnay result in the separation of enough eleetrical charge to cause local discharges resembling normal lightning, as sometimes seen in dust and snow storms. Ball lightning is also a possibility.

Examples of Miniature Thunderclouds

XI. Circa 1919. Stoekton Heath, England.
"1 was staying at Stoekton Heath, in July, about 400 yards from the Manchester Ship Canal. The evening was somewhat oppres- sive, and the air had become strangely still. Gazing down the ruad, I saw a small black thundercloud gathering along the length of the canal, and about 30 or 40 feet above it. It was approximately 400 yards long and perhaps 6 feet thick As I gazed at this strange formation, a dazzling lightning flash raced through the enttre cloud, i.e. parallel to the water, and a bang like the díscharge of field artillery followed immediately.
About 40 seconds later, another flash and report occurred; then the cloud thinned and dispersed in about four minutes. I might add, that at ieast in those days an air eur- rent of varying intensity moved up that canal almost incessantly, i.e. miaml towards Manchester, at the Stoekton Heath section, one felt it on the neighboring bridge. " (RI)

X2. No date or place gíven. Reference to a ¿taicment by Acamedician Marcolle that lightning from a cloudlet 1 1/2 feet in diameter killed a woman. (R2) Obviously this datum is too vague to be of much use, although the cloudlet might have been a form of ball lightning (GLB).

References

RI. Bailey, C. S, ; "A Miniature Thunderstorm, " Weather, 4:267, 1949. (XI)
R2. "Curiosities of Thunderstorms, " Eclec tic Magazine. 38:458, 1856. (X2)

GWC5 Noisy Clouds

Description. Rumbling, grating, hissing, craeklíng low-level clouds showing no evidence of lightning or other electrical discharge.
Data Evaluation. Data are sparse here. The situation is worsened by the great difficulty in eliminating obvious noise producers, such as ínternal electrical discharges. Rating: 3.
Anomaly Evaluation. Noisy clouds, although curious, almost certainly have prosaic explanations. Rating: 3.
Possible Explanations. Unseen electrical discharges are good noise-making candidates. The rattling of suspended hail is another possibility.
Similar and Related Phenomena. The hissing and crackling sounds associated with brush discharge and low-level electrified luminous patches (GLD4).

Examples of Noisy Clouds

XI. 1881. Haute-Garonne, France. "During a recent thunderstorm in Haute-Garonne, RI. Larroque heard a dull continuous sound (like that of heavy carriages on pavement), which could not, apparently, be thunder, and which he accounts for thus: The storm was caused by meeting of two currents, one warm and charged with rain, the other coid and charged with hail. They met prettyhigh up, producing a gyratory storm centre, a cylíndical vortex, ín which the hail was li- quified. The sound is attributed to the hail whirlíng in this cylinder. " (RI)

X2. July 1932. Cache Lake, Ontario. "It was a chilly morning and the sky was com- pletely overcast with clouds. My attention was attracted by a rumbling sound coming from the west, such as heralds the approach of a heavy thunderstorm. As I watched, a very iong, low, narrow, tenuous cloud, re- sembling a squall cloud, appeared above the trees on the opposite shore, moving atright angles to its length. The continuous, rumbling noise, now grown remarkably loud, seemed to come unmistakably from this cloud, whose cross-sectional diameter was only about 200 feet. The cloud passed over- head eastward and was not followed by the expected rain storm. The cloud apparently marked the meeting place of two oppositely directed currents of air that differed in temperature. It seems almost íncredible, however, that so much sound could have arisen from the agitated air alone, and yet this seems to be the only plausible explanaron of its origin. I steadfastly looked for small lightning flashes in the cloud and saw none, although they would have had to come in rapid buccession to produce the persis- tent sound which was heard. The noise could not have come from the rattle of hail because the cross-section of the cloud was too small to give time for hail formation; and in any case no hail fell. " (R2)

X3. February 1969. Jacksonville Beach, Florida. Two clouds emitting sounds like "rattling cellophane" and "someone wal- king on pebbles." The clouds disappeared when they reached the Atlantic. (R3)

References

RI. English Méchame, 34:11, 1881. (XI)
R2. Zeleny, John; "Rumbling Clouds and Luminous Clouds," Science, 75:80, 1932. (X2)
R3. Associated Press dispatch, reprinted in Pursuit, 2:32, April 1969. (X3)

GWC6 Noctilucent Clouds

Description. Very high, glowing clouds seen at high latitudes (45° to 70°) during the sum- mer months. Noctilucent clouds, which often have band or wave structures occur at altitudes of about 50 miles and are illuminated by the sun, which may be well below the obser- ver's horizon. These clouds are always white with perhaps a tinge of blue. The anoma- lous aspects of the phenomenon are intrinsic in the following questions: (1) Where do the nucleating particles and water vapor come from at such extreme altitudes; (2) Why the band and wave structures; (3) Why do the clouds form only at high latitudes during the summer; and (4) Why are they formed at such a narrow range of altitudes?

Background. Rockets probing the región of noctilucent cloud formation in the 1960s at first indicated that noctilucent clouds were composed of ice crystals formed around meteoric dust particles. (Rl) Later experiments cast doubt on these results. (R2) Many unknowns still remain in this field; so many that noctilucent clouds are included in this catalog. The literature on the subject is extensive, and no attempt has been made to gather it all.(R3)

Data Evaluation. A common phenomenon in high latitudes. Ratíng: 1.
Anomaly Evaluation. The questions raised above about the origin and distribution of noctilucent clouds probably have simple answers. Rating: 3. However, ¡f the time-space distribution of noctilucent clouds is due to the nonuniform distribution of meteoric dust, this rating would have to be revised.

Possible Explanations. The banded structure may be the result of high-altitude gravity waves, but no one yet understands their origin either. The concentration of these clouds at high latitudes during the summer could be the result of moi6ture being carried to high altitudes by turbulence during the warm months. Meteoric dust or ions and molecules released by meteors may be nucleating agents. Rocket launches may also contribute. (R4)

Similar and Related Phenomena. The same sort of banded structure is found in the banded sky (GLA23), magnetically aligned cirrus clouds (GWC3), and some air-glow events (GLA3).

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R4. Meinel, Aden B., and Meinel, Carolyn P.; "Low-T.atitude Noctilucent Cloud of 2 November 1963, " Science, 143:38, 1964.
R5. Weisburd, S.; "Mysterious Clouds Caused by Cosmoids?" Science News, 129:344, 1986.

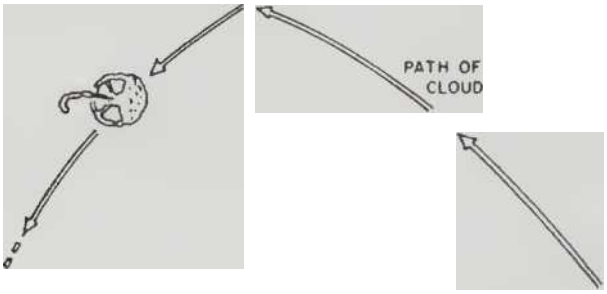
GWC7 Ring Clouds

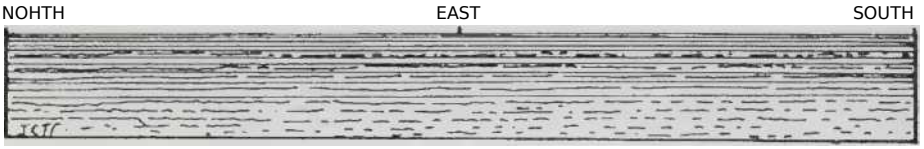
Description. Circular clouds with clear centers----------like 'smoke rings'-------which in many cases seem to roíate about the axis of the circle. Most ring clouds move at normal cloud levels, but examplec at 30-railes-altitude have been reported.
Data Evaluation. Several good observations plus photographs. Rating: 1.

Anomaly Evaluation. Ring clouds are probably just the consequence of freak local meteoro- logical conditions that generate small vortexes. No significant anomaly here. Rating: 3.

Possible Explanations. Pressure, temperature, and wínd measurements made during the passage oí a ring cloud confirm the presence of a small, local vortex. The precise origin of these small vortexes is not known. High-altitude ring clouds, which seem rare, may just be aberrant nacreous clouds; that is, accidentally distorted into rough circles.

Similar and Related Phenomena. Circular holes In cloud decks (GWC9).





Ring cloud with spokes and tail (X1)

Examples of Ring Clouds

XI. March 22, 1870. North Atlantic Ocean. "At from 0.30 to 7 P. M. a curious-shaped cloud appeared in the S. S. E. quarter, first appearing distinct at about 25° from the horizon, from where it moved steadily for- ward, to about 80°, where ít settled down bodily to the N. E. Its form was circular, with a semicircle to the northern face near the centre, and with four rays or arms ex- tending from centre to edge of circle. From the centre to about 6° beyond the circle was a fifth ray broader and more distinct than
the others, with a curved end:------diameter of circle 11°, and of semicircle 2 1/2°.
The weather was fine, and the atmosphere remarkably clear, with the usual Trade sky. It was of a light grey colour, and, though distinctly defined in shape, the patches of cirro-cumulus at the back could be clearly seen through. It was very much lowerthan the other clouds; the shape was plainest seen when aoout 55° to 60° high. The wind at the time was N. N. E., so that it carne up obliquely against the wind, and finally set tled down right in the wind's eye; finally lost sight of it through darkness, about 30° from the horizon at about 7.20 P. M. Its tail was very similar to that of a comet."
(H1) This observation is frequently refe- renced in the Fortean literature. (WRC)

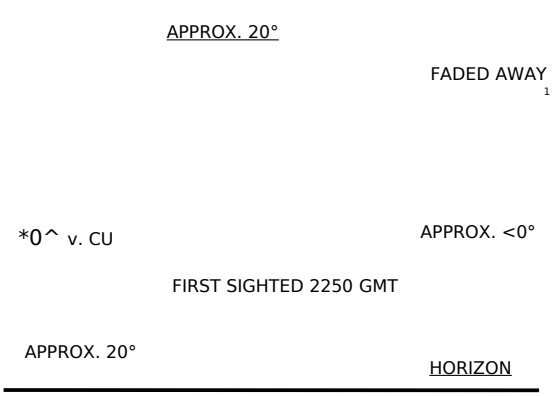
X2. December 5, 1922. Biggin Hill Aero- drome, England. A cloud ring, 60° india- meter , moved across the sky, with stars oc- casionally visible in the center. "The phenomenon was íike a great smoke ring." The ring broke up after passing through zenith. (R2)

X3. February 1, 1958. Gulf of Aden. "At 2300 S. M.T. a cloud, in the form of a circle about 1 mile in diameter, was observed Iving above and ahead oí the patl) of the ship. When the vessel carne nearer, the cloud was clearly seen in the moonlight. to be re- volving in a clockwise direction. The centre of the circle was completely cloudless. While passing under the cloud there was a fall in barometric pressure of 3. 5 mb and a 3º droo in temoerature. The sea also

was noticeably calmer under the clear sky. As the vessel left the aren, both pressure and temperature reverted to their former valúes. The wind which had been NE., forcé 4, for a long tíme, veered completely round whlie the vessel was passing under the cloud. and finally settled again in the NE. quadrant, al forcé 3. When last seen, the cloud formation was thought to be brea- king up. The phenomenon observed lasted for a little over 15 mln. " (R3)

X4. November 1, 1962. Red Sea. Cloud resembling a huge smoke ring moves northeast while rotating antíclockwise. (R4)

X5. November 27, 1980. North Atlantic Ocean. "At 2250 GMT a glowing 'smoke ring' phenomenon was observed on the star- board quarter at approximately 20° altitude and bearing approximately west. It moved towards the stern and climbed in the sky, disappearing behind a cloud and reappear- ing on the other side before finally fading away at approximately 40° altitude, bearing WNW, at 2255 GMT. The diameter was about 3-4° and the centre seemed to be dar- ker than the surrounding sky when viewed through binoculars." (R5)



Smoke ring phenomenon in the North Atlantic (X5)

X6. February 28, 1963. Arizona. "Abstract. An unusual ring-shaped cloud was widely observed over northern Arizona near sunset on 28 February 1963. From a large number of observer's reporta it is known to have appeared overhead near Flagstafí, Arizona. From initial computations based on íour photos taken in Tucson, 190 miles south of the cloud, its altitude was approximately 35 kilometers. I'he most distant observation reported was made 280 miles from the cloud. The cloud remained sunlit for 28 minutes after local sunset. Iridescence was noted by many observers. Tentatively, the cloud may be regarded as similar to a nacreous cloud; but its unusually great height and un- usually lew altitude, plus its remarkable shape, suggest that it was a cloud of pre- viously unrect.rded type. " (R6, R7) In the last sentence of the quotation, "altitude" evidently means "angular elevation, other- wise the sentence makes little sense.

X7. June 15, 1963. North Pacific. Aboard the S.S. Elizabethport enroute from the Panama Canal to Long Beach, California "..,.an unusual cloud was observed. It was composed of four concentric rings and puré white. It bore 280°, altitude 35°. It appeared above large cumulus clouds which were tinged with gray and palé yellowish tints. Two other clouds similar but of less regular formation were observed at the same time."

There is no recognized meteorological mechanism that produces concentric ring clouds. However, rocket launches may create weird cloud formations. This ship’s position <7°10’ N. 81°26’ W) and the cloud’s azimuth make the missile explanation unlikely, even for launches from California. (R8)

X8. 2002. Germany. "Flying over the Germán Bight at about 13,000 metres I saw a completely annular cloud. It appeared unrelated to the other scattered clouds that were present and, for the two minutes I was able to watch it, it didn’t change its appearance. It must have been 3 to 4 kilometres across and 300 or 400 metres thick, though this varied around its circumference."(R9)

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GWC8 Thunderclouds Affecting the Ionosphere

Descriptions. Sharp increases in the level of sporadic E íonization Ln the lonosphere cor- related with the passage of thunderstorms.

Data Evaluation. A single series of experiments in a single locality. Rating: 3.
Anomaly Evaluation. Thunderstorms occur in the lower atmosphere, whereas the E layer of the ionosphere exists between 50 and 85 miles altitude. How are the two phenomena con- nected physically? Rating: 2.

Posstble Explanations. A channel of lower electrical conductivity may be established between the ionosphere and lower atmosphere by penetrating radiation.

Similar and Related Phenomena. Low-level auroras (GLA4); luminous phenomena above thunderstorms (GLL1); correlation of thunderstorms and cosmie rays (GLL16); correlations of auroras and thunderstorms (GLA9). Chapters GLA and GLL are in Remarkable Luminous Phenomena.

Examples of Thunderclouds Affecting the lonosphere

XI. 1953 and 1954. Calcutta, India. The level of ionoization in the sporadic E layer of the ionosphere was found to increase sharply with the passage of thunderclouds over Calcutta. The authors ventured that thunderstorms might be one of the causes of sporadic E ioniza- tion. (RI)

References

RI. Mitra, S.K., and Kundu, M.R.; "Thun- derstorms and Sporadic E Ionization of the lonosphere," Nature, 174:798, 1954. (XI)

GWC9 Circular Holes in Cioud Decks

Description. Circular holes several miles in diameter that form in otherwise dense, uni- form cioud decks. Horn-shaped tails under the holes may infer precLpitation.

Data Evaluation. Several modern observations complete with series oí photographs. Rating: 1.

Anomaly Evaluation. Holes in cioud decks are symptomatic of natural or artificial seeding. In the observations recorded here, no artificial seeding was known to have occurred in the affected areas. The problem relates to what natural phenomenon seeded the cioud deck. Several candidate phenomena are available, so that circular holes in cioud decks are very likely only minor anomalies. Rating: 3.

Possible Explanations. Besides intentional cioud seeding for purposes of weather modifica- tion, rockets, aircraft, and even ground-based industries may contribute hucleating mater- ials. Natural seeding may initiate from higher-level clouds.

Similar and Related Phenomena. Black spots on satellite images of the earth's airglow (GWC20).

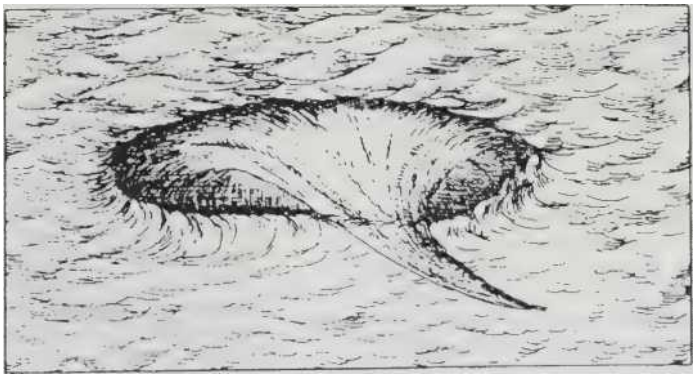
Examples of Circular Holes in Clouds

XI. December 1, 1967. Miami, Florida. 0830 EST. "At about this time one of us in- dependently noted a distinct downward pro- trusion of what appeared to be middle cioud below the base of the otherwise uniform altocumulus layer. By 0900 EST the holes were conspicuous almost perfect circles. The sketch of the Southern hole... .depicts conditions observed at about 845 EST. A well-developed cirrus tail extended down from this hole, and trailed off approximate- ly west-northw'estw'ard, thus indicating a downward decrease in wind speed." Some spectacular photographs attest to the nlce circularity of the two holes, each of which measured about 4 miles in diameter. Some sort of natural cioud-seeding procesa was suspe cted. (Rl)

X2. February 23, 1968. Vandenberg Air Forcé Base, California. A circular hole, about 6 miles in diameter, was observed in a círro- cumulus cioud deck at 26,000 feet. (R2)

X3. General observations. In 1985, P.V. Hobbs reviewed the "hole-in-cloud" phenomenon in Weatherwise.

FirBt, he reminded meteorologists that unusual, roughly circular holes in cioud decks have been reported for at least 60 years and the first photographs taken in 1926. He includod n long list of profferred explanations ranging from downbursts of coid air to UFOs. The two



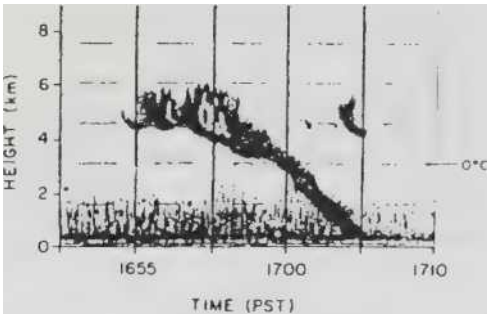
Circular hole ¡n cioud deck with a cirrus tall (X1)

favored theories involve: (1) fallstreaks of ice crystals from clouds above that in effect puneture a hole in the affected cloud deck; and (2) aircraft ascending or descending through the cloud deck.

Actually, fallstreaks of ice crystals are rather common. Most of them do not reach the ground. They have roughly the same effects as the artificial seeding of clouds with such crystals as sodium iodide. Often though, holes appear in cloud decks in the absence of higher clouds that might release fallstreaks of ice crystals.

It is known, too, that the propellers and wings of aircraft flying through clouds may stimulate the formation of ice crystals. TheBe crystals are called APIPs (Aircraft-Produced Ice Particles). If con- ditions are favorable, holes-in-clouds may appear about half an hour after a plañe has passed through a cloud deck.

In some well-publicized cases (XI), however, neither fallstreaks ñor aircraft are involved, leaving the mystery partly unsolved. (R3)



A radar-de tecleó fallstreak from ar¡ clíocumulus cloud, probably resulting in a visible hole in the cloud. (R3)

X4. November 9, 2000, Melbourne, Florida. We quotc from Florida Today. (R4)

> An unusual cloud formation appeared in the skies over the Space Coast on Thursday caused by ice crystals and enhanced by the jet stream — The National Weather Service calis the formation "hole-punch" clouds because of the oval-shaped opening
>
> The atmosphere on Thursday was very dry from about 5,000 to 28,000 feet. There was a rather extensive deck of cirrocumulus (mixture of "supercooled" water droplets and ice crystals) invading the sky associated with strong westeriy jet-stream winds.
>
> However, the 'hole-punch' features were aligned north/south. This sug- gests that there was some sort of 'wave' in the atmosphere that was causing rising/sinking air couplets.
>
> This would cause ice crystals in the descending portion of the wave to fall into the supercooled (liquid) cloud layer. When this occurs, the ice crystals grow (at the expense of the liquid droplets). Therefore, a hole opened in the deck of the cirro-cumulus .
>
> This process is similar to the principie used in cloud seeding to make cloud particles larger and produce precipitation. In this case, the pre- cipitation aloft (meteorological term is 'virga') descended into the dry air below 28,000 feet and evaporated.
> (R4)

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GWC10 Anomalous Cloud Lines and “Streets"

Description. Lines of clouds, often hundreds of miles long and teñs of miles wide, many without obvious causes. Anomalous cloud lines appear predominantly over the oceans.

Background. When high-resolution satellite photographs of the earth's eurface becameavail- able in the 1960s, many showed anomalous cloud Unes over ocean arcas. At first, they were believed to be the eontrails of ships. Later studies conclude<l that several other fac- tors were also operating (see below) and that some had no obvious explanation.

Data Evaluatlon. Abundant, liigh quallty satellite photographs. Eating: 1.
Anomaly Evaluation. Due to the multlplicity of reasonable explanations, anomalous cloud Unes must be considered mainlv as curiosities, although the precise method of formation of some remainsunknown. Ratíng: 3.

Possible Explanations. Ship and aircraft eontrails, meteor trails (rare), orographic clouds formed in the lees of oceanic islands, and clouds formed over linear perturbations in sea tempcraíure arislng from currents and internal waves.

Similar and Related Phenomena. Múltiple, long, parallel roU clouds (GWC12); polar bands (GWC3); luminous nocturnal streaks (GWC32); banded skies (GLA23 in Re markabic Luminous Phenomena) . —

Examples of Anomalous Cloud Lines

XI. General observation. "Satellite cloud photography oecasionally reveáis anomalous cloud Unes in the form of plumes often 500 km long and up to 25 km wlde. These lines, found over the ocean, are composed of Uq- uid partióles, ilollow polygonal, convectivo or thín stratiform, cloud patterns in varying amounts are associated with these Unes. Numerous Unes within a 10-deg squarehave been nbserved which cover up to 4 per cent of the total aren." In the author's opinión the cloud lines are exhaust plumes from ships. (RI)

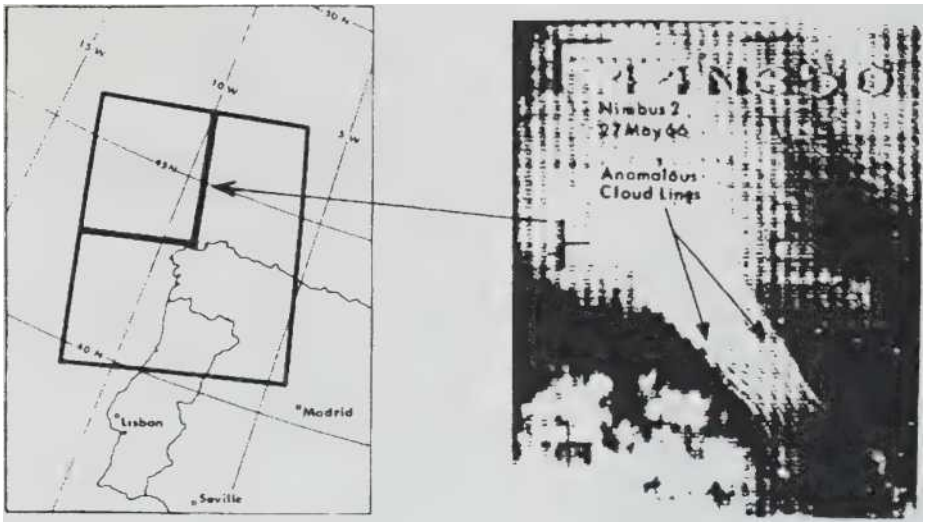
X2. June 27, 1967. North Pacific Ocean. "On June 27, 1967, the ESSA 2, automatic plc- ture transmission (APT) photograph, taken at 1720 GMT, showed anomalous cloud Unes. B. J. Haley, pilot of United Airlines fllght 185-27, flew over this area at 1945 GMT. He reported no clouds or vapor trails ai his flight level of 31,000 fl. Below him, he ob- served a layer of low, thin stratus through which sunlight, reflected from the ocean, could be seen. He estimated the height of the stiatus layer to be 1,000 ft above the surface. Haley also reported that a ship lo- cated near 35°N, 131 °W and traveling due east was clearly visible through the stratus layer. The smoke from the ship's ttackwas forming a 'definlte line of thicker clouds' In the layer of scattered and broken siratus. This condensation trail was estimated to be 2-4-m! wlde at a point 10 mi behind the ship, and to extend 125-150 mi beforc fading out." **(H2)**

X3. General observation. After reviewing the problera, the authors concur with the ship exhaust theory. (R3)

X4. General observations on various satellite photus. "Anomalous cloud lines are depicted in Fig. 1, which was taken off the westcoast of the United States (the date and time of the imagery are unknown). This is a DMSP pro- duct, d ay ti me visual imagery with a 1/3 n mi resolution. An extended band *u*f stratoeumu- lus clouds, tops at 1200 m is shown. The upper left diagonal half of the pieture contains a mínimum of five anomalous cloud lines. Cióse examination revealed the majority of these lines to be connected to iayers of clouds. Studies were performed by the First Weather Wing. Air Weather Service, using DMSP visual and infrared data in the early ’70s. Hundreds of anomalous cloud lines similar to Fig. 1 were studied in an attempt to relati the linos to ship smoke trails. The following conclusions were do— rived: (1) All the Unes consistod of strato- cumulus type clouds with tops ranglng from 1000 to 1400 m. (2) A U.S. Navy investiga- tion at Pearl Harbor revealed that no ships were at the ends of any of the Unes. In fact, most of the lines occurred above the ocean surface away from the rr.ajor shipping Unes. (3) lt was concluded that the Unes were ran- dom cloud activitv oriented with ocean gradiente. " Several of the photographs examined showed cloud lines that could not be attribu- ted to any artificial, meteorological, or oceanographic rondltions. (R4)

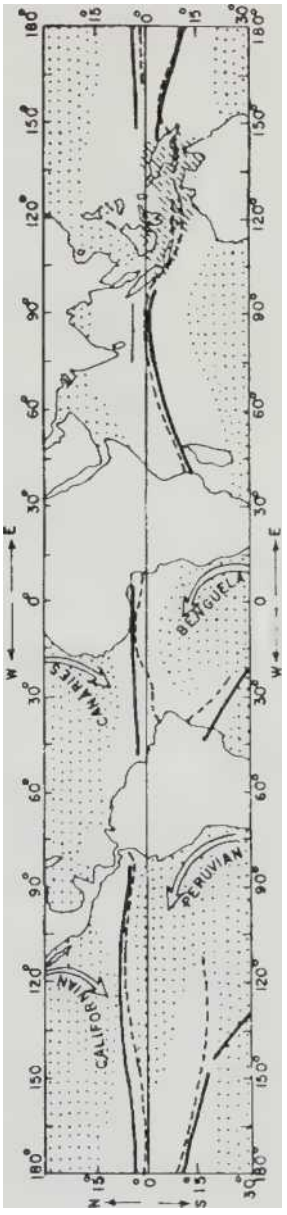
GWC10 CLOUD LINES AND "STREETS"

Satellite photo of anomalous cloud Unes (Fig. 1 from R4) (X4)
(Courtesy H. IV. Brandii)



System of anomalous cloud Unes taken from the satellite Nimbus 2 off the coast of Spain <X4) (Courtesy H. IV. Brandii)

X5. Frequent occurrence. Tropical oceans.
"Summary. Available observational evidence regarding occurrence of double cloud bands, one in each hemispbere, over tropical oceans is reviewed. An examination of their locations appears to suggest that these may be related to maxima in ocean surface tem- perature. Significant asymmetry and dis- continuity are noticed over areas which are affected by coid ocean currents and mon- soons.
”1. Observational Evidence. Duríng tbelast quarter century or so, there have been oc- casional references in literature to the oc- currence of double cloud bands in the tropical zone, although definitive information regarding their origin, nature and locations relative to the Equator in different regions has been rather scanty. The earliest ref- erence appears to be that of Fletcher <1945) who cites aircraft reports of frequent occurrence of double cloud lines, one on each side of the Equator, in equatorial eastern Indian Ocean duríng autumn through spring. Recently, after the introduction of Meteorológica! satellites, double cloud bands have been observed in other parts of the Tropics as well."
The salient features of the double bands are:
”(i) Double cloud bands are characteristic features of all tropical oceans; (ii) The cloud bands do not cross the Equator in any región;
(iii) The intensity of the cloud bands gene- rally varíes with the seasons, the summer hemispheric band being the more intense.
(iv) In some regions such as the equatorial western Pacific, the cloud bands in boththe hemispheres lie cióse to and are more or less parallel with the Equator. In equatorial eastern Indian ocean, the cloud bands during February also lie cióse to and more or less parallel with the Equator. In the Atlantic and eastern Pacific, while the northem hemispheric cloud band lies cióse to and more or less parallel with the Equator, the Southern hemispheric cloud band is displaced from the near-equatorial position and lies oblique to the Equator. (v) The continuity of the cloud bands in both the hemispheres is brokenover some oceaníc regions. Prominent among these regions are south-eastern Pacific, south-eastern Atlantic and western Indian ocean especially the western Arabian sea.
(vi) in the monsoon regions, while the cloud band ín the summer hemisphere is attracted to the continental landmass, that in the win- ter hemisphere shifts little from its near- equatorial position. J’he cloud bands are thus widely separated (rom each other. These effects at< most prominently seen in the regions of thí summer monsoon of Asia and Australia." (R5)



February double-cloud bands (solid lines) and lines of maximum ocean temperatures (dashed lines) (X5)

X6. February 25, 2000. Western Europe. A photograph taken from satellite NOAA- 14 shows lee waves over Scotland orien- ted at right angles to "cloud streets"
over Southern Britain---even though both are in the same air stream. The situation is described further in Weather.

"Over lowland England the clouds are arranged in lines, called cloud streets, approximately parallel to the low-level wind in an inversion-topped boundary layer. These cloud streets are very striking in the north-westerly flow over the Low Countries in continental Europe. Here, surface warming on a sunny day allows the convection layer to grow in depth further inland, as do the clouds. Eventually, the convection is vigorous enough to overeóme the stability aloft which keeps them in streets." (R6)

No attempt is made in the article to explain the origin of cloud streets or their right-angle relation to the lee clouds.

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GWC11 Dispersal of Clouds by the Moon

Description. The tendeney of clouds to disperse under the influence of the moon, particu- larly the full moon.

Background. Folklore has long stated that "the moon eats clouds. " Scientiflc analyses have been both positive and negative in this matter------more negative than positlve in the long run. Modern Science looks with disfavor on the folklore assertion but nevertheless has found some evidence that supports the reality of a lunar influence on rainfall (GWS1), which in essence llnks the moon to cloudiness or the lack of it.

Data Evaluation. Several conflictlng studies and many disagreeing opinions by observers of the night sky. Rating: 3.

Anomaly Evaluation. Moonlight should have no dlrect effect on clouds, but if it seems to there are at least two reasonable explanations (see below), a situation rendering this phe- nomenon "not very anomalous. " Rating: 3.

Possible Explanations. Scientists agree that there is a tendeney for clouds to disperse in the early evening (a solar effect?), which is precisely the time most people would notice a full moon if it were in the sky. Consequently, what is really coincidental might be labelled cause-and-effect. Some studies suggest that the moon's phase can be correlated with rainfall (GWS1) and suggest this effect may be due to the moon's gravitationai field affecting the influx of meteoric nucleating debris, providing a cause-and-effect relationship between the moon and cloudiness.

Similar and Relaled Phenomena. The moon and the weather (GWSI).

Exaxnples of the DIspersal of Clouds by thc Moon

XI. General observation. Greenwich, Eng- land. Noting that Sir John Herschel had proclaimed that the full moon tended to disperse clouds, the author analyzed 7 years of cloud data recorded at Greenwich Observatory. Conclusión: the moon has no effect on general cloudiness. (RI) X2. General observation. Greenwich, Eng- land. A study similar to XI, also uslng Greenwich cloud data. Same conclusión. Author noted, bowever, the tendency of the sky to clear in the early evening re- gardless of the moon's position. SInce the full moon is always conspicuous at this time, the two unrelated phenomena might be assumed to have a cause- and- effect relationship. (R2, R6, R7)

X3. General observation, Batavia, Java. ”In the appendices to the volumes of obser- vations at Batavia, Dr. van der Stok publl- shes studies of the influence of the moon on the meteorological elementa. He finds an appreciable effect on the cloudiness. The cloudiness there increases with the increase of the distance of the moon above the hori- zon, reaching its máximum at the superior meridian transit and its mínimum at the inferior one. Thus the influence of the moon appears to be felt when she is below the horizon, which exeludes the hypothesis of its being the result of direct radiation. There is also greater cloudiness at full than at new moon. In each case the extreme dif — ference averages about 5 per cent." (R3)

X4. General observation. Several obser- vers in mountainous regions have con- cluded that the full moon does indeed tend to disperse clouds. (R4) No further details given. (\VRC)

X5. General observation. England. Analy- sis of 15 years of data showed no effect of the full moon on cloudiness. (R5)

XG. January 4, 1912. Dublin, Ireland. "This somewhat rare phenomenon could be observed here, Jan. 4d. 20h. 30m. to 21h. Two air-currents, the upper from S. S. W., and lower from W., carried theír strataof clouds aeróse the moon's disc. The lower clouds traveled at avery fast rate, while the lunar disc seemed to rise up to meet them as it advanced from E. The swiftlyad- vancing clouds, on coming in contact with the moon's North Polar Región, instead of passing aereas the disc, coasted round it and drifted on their way. At times thescat- tering was directed in all directions, just as a piece of ice thrown on a frozen pond breaks and scatters broadeast. " (R8) This may only have been a contrast effect, with bright moonlight seeming to make the thin clouds invisible. (WRC)

X7. 1908-1911. England. Of the 50 full moons during this period, 31 appeared to disperse clouds. (R9)

X8. General observation. Observations , such as thoseof X6, are merely matters of perspective; i. e., clouds seem to thin out when viewed directly overhead. (RIO) X9. General observation. England. An amateur astronomer avers that the full moon, in his experience, indeed does disperse clouds. (Rl 1)

X10. General observation. The brightness of the full moon makes thin clouds seem to disappear; i.e., apparent dispersa! is a matter of contrast. (R12)

XII. General observation. "The moon's changing faces, already linked to heavy rain- fall, are also related to sunshine. There is more sunshine than usual when the moon is between first quarter and full moon, and be- tween last quarter and new moon. Below av- erage sunshine occurs between new moon and first quarter, and between full moon and last quarter. This relationship was reported to the American Meteorological Soctety mee- ting in Vancouver, Cañada, by Iver A. Lund of the U. S. Air Forcé Cambridge Research Laboratories, Bedford, Mass. He studied weather records covering 58 years, from 1905 through 1962, for ten cities, a tota! of more than 211,000 observations." (R13)

X12. Frequent observation. Oxford, England. Re: the cloud-dispersing capablity of the moon. "From repealed observations it appears that at Oxford the influence begins after the moon is four or five days oíd, and lasts till she approaches the sun agaln the same distance on the other side. So frequent- ly has this been noticed by Mr. Johnson, that during a course of observations on which he was engaged a few years ago, he felt that his attendance at the observatory could not be dispensed with, however unpromlsing might be the appearance of the night, until the moon had fairly risen; and over and over again when this has occurred, the sky, before com- pletely obscured, has become clear. "(R14)

X13. Frequent occurrenee. R. Bauni is a well- respected British amateur astrono- mer and writer on celestial matters. His opinions are the result of long experience with telescopio observations. Iri

his classie book The Planets, he made the following statement in connection with preparations for a search for natural lunar satellites at Flagstaff, Arizona, in 1956. "It is well known that there is a tendency for cloud to disperse about midnight when the Moon is full and cióse to the zenith.ⁿ (R19)

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R19. Baum, Richard; The Planets, New York, 1973, p. 42. (X13)

GWC12 The Morning Glory Phenomenon

Description. Long, spectacular roll clouds that usually advance rapidly in an otherwise nearly cloudless sky, bringing sudden wind squalls but little or no precipitation. Most occur in the morning, but evening glories are known. Rarely, two morning glories advancing from different directions will ínterseet one another.

Background. This phenomenon is most frequent in northern Australia's Gulf of Carpentaria. However, reports of analogous phenomena from Africa and North America exist.

Data Evaluation. Many scientific and popular articles make the morning glory a well-known phenomenon. Rating: 1.

Anomaly Evaluation. The morning glory has been termed a solitary wave, an undular bore, and/or a hydraulic jump. Details of the conditions that initiate the phenomenon are not well- understood, particularly the southerly Australian morning glories- Rating: 3.

Possible Explanations. Morning glories are propagating cloud lines analogous to tidal bores and solitary «aves.

Similar and Related Phenomena. Anomalous cloud lines (GWC10) are similar but do not propágate. Better analogies are tidal bores and solitary waves in bodies of water (GHS3 in Earthquakes, Tides .

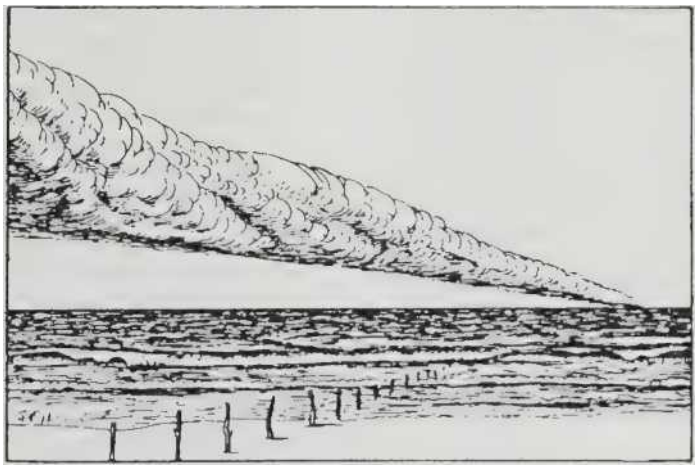
Examples of the Morning Glory Phenomenon

XI. Frequent occurrence. Gulf of Carpen- tarta, Australia. "The Morning Glory cloud assumes the form of an arch or bow stret- ching across the sky but its lateral dimen- sions are generally uniform along its entire length—the arched appearance to theground observer being produced by perspective, The cloud is only 100-200 m thick and is verylow (the highest base reported is 500 m but some as low as 50 m have been observed). Both the bases and the tops are quite regular and well defined but often the tops are inclined ahead of the bases. This gives a rolling ef- fect but the cloud is not always observed to be actually rotating. One of the most re- markable features of the Morning Glory is its great length. Ground observers fre- quently report it as exlending from one ho- rizon to the other, and an aircraft pilot once flew along one for 120 km withoul Cornıng to the end .....double Morning Glories are commonly reported and as many as se- ven suecessivé rolls have been observed. They are usually oriented north-north-west to South-south-east and move from east to west at speeds whích range from 10 to 25 m s^{-1}. In cases of múltiple rolls thewhole entourage may take more than an hour to pass. The clouds do not usually produce precipitation but a fine mist sometimes oc- curs with múltiple rolls." (R1-R3)

X2. October 5, 1979. Camooweal, Australia. Two closely spaccd, propagating, cumulus cloud Unes, extending from horizon to horizon. (R3)

X3. July 25, 1979. Julia Creek, Australia. Horizon-to-horizon cumulus line propagating over a fealureless plain at 12 m s^{-1}. (R3)

X4. October 1980. Gulf of Carpentaria, Australia. Southerly morning glories.
The Gulf morning glories rarely approach from the south. Their origin is debatable. We quate from a summary of an observa- tional expedition by R.K. Smith ct al. "Observations made during an expedition in October 1980 to study 'morning glory' wind squalls in the Gulf of Carpentaria región of Northern Australia are de- scribed. During a ten day period in Burketown, north Queensland, six squalls were documented on consecutive



The Morning Glory, a spectacular roll cloud (X1)

mornings (8-13 October) including two moving from the south, an apparently unusual direetion. The unique data gathered from the latter confirm that these have the same character as their north-easterly counterparts; that is, they are undular bores. The origin of southerly glories remains uncertain, but, at least, in some cases, seems to be linked with the advance of a frontal trough across central Australia." (R6) (See also RIO)

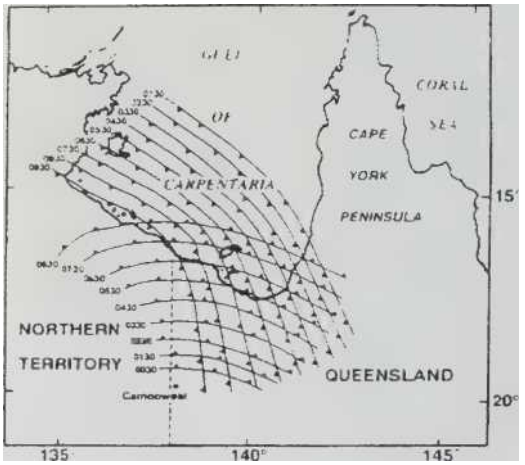
X5. Occasional occurrence. Invisible morning glories. These can be dangerous to aircraft, as now discussed. "And while the Coastal weather conditions in Burketown [Australia] create a clearly visible cloud, elsewhere in the world these atmospheric waves form in dry air, creating an invisible menace that can cripple aircraft in midair or suddenly fling a plañe off its runway approach. If your pilot can't see the wave coming, you could be in big trouble." (R15)

In the United States, tornado obser- vation networks can detect invisible morning glories as they pass by. (R15) (See X9)

X6. January 18, 1979. The Gambia, Africa, C.P.A. White observed an even- ing glory. "I was birdwatching in a coastal mangrove swamp when 1 noticed a peculiar band of low-level cloud over the sea to the north, extending from horizon to horizon. As it approached it became apparent that it would be an unusual and violent phenomenon, so we headed back to our cars to take cover. The cloud was smooth and regular, and the leading edge apparently rolling strongly.

"The appearance of the cloud was very similar to that on the cover of Weather for May 1981, although in our case the médium cloud was much more extensive and less ordered. As the roll cloud passed overhead the wind in- creased from calm to forcé seven or eight almost instantaneously, but drop- ped to light after about 90 seconds, as it roared inland leaving light rain be- hind it." (R8)

X7. October 3, 1991. Gulf of Carpen- taria, Australia. Interactive morning glories. On this day, a northeasterly morning glory (the usual variety) met a southerly morning glory. The tyro clashed over the Gulf waters creating turbulence as they mixed. They passed through each other and resumed their initial courses. (R13)



Isochrones of intersecting northeasterly and ***southerly*** *morning glories in the Gulf of Carpentaria,*

X8. November 12, 1995. Washington, D.C., about 8 P.M., M.T. Shoemaker observed a massive evening roll cloud. "What I saw was a dense, yellow-white, sharply defined, linear cloud roll that stretched from horizon-to-horizon on a Southwest to northeast course. It had an almost self-illuminated brightness, which may have been due to reflection of the abundan! light of Washington's night sky. The cloud's oddest character- istic was that it remained absolutely stationary. The temperature was brisk, and the sky was unusually clear. No other clouds were visible exeept for the roll and one other seemingly unconsoli- dated roll." Later examination of satel- lite photos revealed that this roll cloud stretched 400 miles from Delaware to Kentucky. (R14)

X9. «Tune 9, 1982. Near Oklahoma City, Oklahoma. Eight cloud lines, each about 250 kilometers long. Speed: 15 meters/ second. "Early in the morning on 9 June 1982 a system of traveling wavr cloud lines passed over Oklahoma, and in particular, over the relatively dense mesonetwork of surface stations, inclu- ding the instrumented 444-m KTVY televisión tower, operated by the U.S. National Severo Storms Laboratorv. An analysis of the network and other data presented herein shows that, in struc- ture, the associated disturbance wos an internal undular boro propagating on a low-level stable layer, similar to 'morning glory'-type disturbances, which are coramon at certain times of the year in parts of northern Australia." (R9)

X10. September 2, 1984. F.nglish Channel. A "sausage" roll cloud was eeen from an aircraft. "Some four nautical miles north of 50°N, a cloud bank was seen ahead, at right-angles to the flight path. As they carne level to it, the pilot and his two passengers were amazed to find that it was, in fact, an enormous long sausage shape, perfectly circular in croes- section, extending from a few hundred feet above the sea to a level top at 2000 ft (610 m). There was little wind and the roll of cloud appeared to rotate around its axis." (R12)

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RI. Neal, A. B., et al; "The MorningGlory," Weather, 32:176, 1977. (XI)

R2. Clarke, K. H., et al; "The Morning Glory of the Gulf of Carpentaria: An Atmo- spheric Undular Bore," Monthly Weather Review, 109:1726, 1981. (XI)

R3. Christie, D.R., et al; "Solitary Waves in the Lower Atmosphere," Nature, 293: 46, 1981. (X1-X3)

R4. Clarke, R.H.; "The Morning Glory: An Atmospheric Jump," Journal of Applied Meteorology, 11 :304, 1972.

R5. Clarke, R.H.; "The Morning Glory," Weather, 32:176, 1977.

R6. Smith, Roger K., et al; "The Morning Glory: An Extraordinary Atmospheric Undular Bore," Royal Meteoro- logical Society, Quarterly Journal, 108:937, 1982. (X4)

R7. Clarke, R.H.; "The Morning Glory," Weatherwise, 36:134, 1983.

R8. White, C.P.A.; "Bvening Glory in The Gambia, West Africa," Weather, 39:29, 1984. (X6)

R9. Ilaase, Sabine P., and Smith, Roger K.; "Morning Glory Wave Clouds in Oklahoma: A Case Study," Monthly Weather Review, 112:2078, 1984. (X9) RIO. Smith, Roger K., et al; "Southerly Nocturnal Wind Surges and Bores in Northeastern Australia," Monthly Weather Review, 114:1501, 1986. (X4) Rll. Drosdowsky, W., and Holland, G.J.*, "North Australian Cloud Lines," Monthly Weather Review. 115:2645, 1987.

R12. Capstick, G.M.; "Sausage Roll Cloud," Weather, 43:302, 1988. (X10) R13. Reeder, Michael J., et al; "Inter- acting 'Morning Glories' over Northern Australia," American Meteorologieal Society, Bulletin, 76:1165, 1995. (X7) R14. Shoenaker, Michael T.; "Anomalous Cloud Roll Documented," 1NFO Journal, #74:41, Winter 1996. (X8) INFO = International Fortean Organization.

R15. Torok, Simón; "Morning Glory," New Scientist, p. 34, Januarv 20, 2001. (X5)

GWC13 Long, Hollow, Cylindrical Clouds

Description. Long, white clouds Ln the shape of hollow cylínders, 300 or so feet in diameter and on the order of 100 miles long.

Data Evaluation. Only a single observation. Rating: 3.
Anomaly Evaluation. Since several reasonable explanations exist, this phenomenon is in- cluded primarily for its curiosity valué. Rating: 3.

Possible Explanations. A smoke and/or dust trail left by a large, low-altitude meteor; a roll cloud like the Morning Glory (GWC12) at unusual heights; an aircraft contrail (not especially likely in XI due to date and location).

Similar and Related Phenomena. Anomalous cloud lines (GWC10), the Morning Glory Phenomenon (GWC12).

Examples of Long, Hollow, Cylindrical Clouds

XI. February 7, 1948. North Atlantic Ocean. Altitude: 10,000 feet; time: 1145 GMT. "At this time, an apparent condensation trail was seen overhead against a blue sky. (The pilot) added that he would hesitate to estímate the height to which the east end of the trail was visible, but that it was certainly higher than indicaied on the sketch (40,000 feet). As the trail lay almost along the route, the aircraft, by a slight alterationin course, was flown underneath it for 25 minutes and then thru the lower end of the trail. The crew, by looking backwards and upwards from the top of the aircraft, could see into and along the trail. It appeared to be cylin- drical, and about 300 to 400 feet in diameter at the level of flight. The diameter of the upper section must have been considerably larger, judging by the clarity with which it could be observed. The upper end of the trail was clearly defined, while the lower end was diffuse and disappeared at about 8,000 feet. The trail was white at all levels, altho the lower end was somewhat darker than the rest.... it appeared in a straight line, disappearing into the castern sky at great altitude, and in places appeared to be composed of spiral-shaped wisps." (RI)
The trail length was estimated at 60 miles. Its downward trajeetory made a meteoric explanation reasonable. (WRC)

Reference

RI. LaPaz, Lincoln; "A Possibly Meteoric Dust Cloud, " Popular Astronomy, 58: 355, 1950. (XI)

GWC14 Cloud Spokes Radiating from Thunderclouds

Description. Cloud bands or ridges extending spoke-like from thunderclouds.

Data Evaluation. Very few observations, and these are rendered doubtful due to the pro- blem of perspective. Rating: 3.

Anomaly Evaluation. Radial cloud structures are rare in meteorology and current theory offers no hints on why cloud spokes should radíate from thunderclouds. Rating: 2.

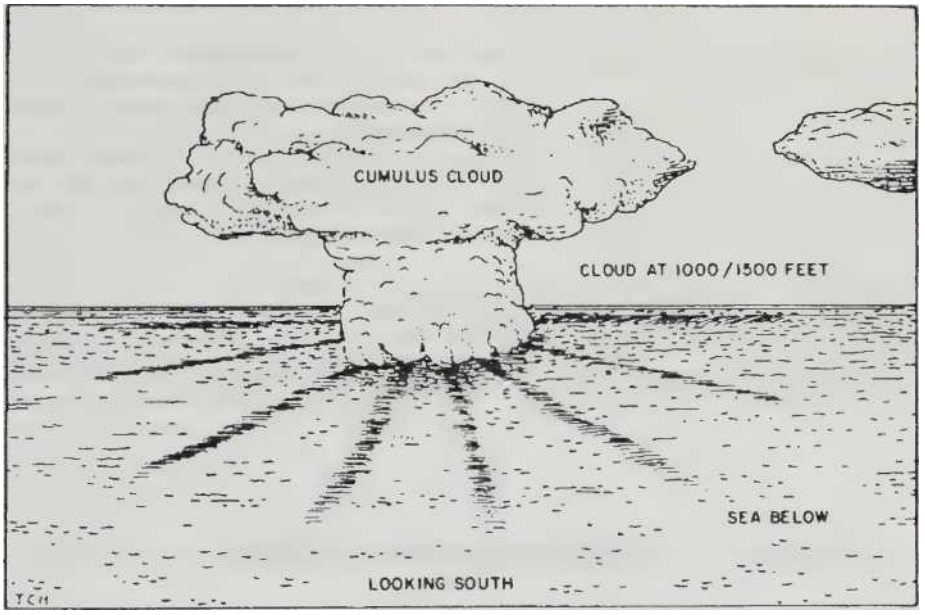
Possible Explanations. Conceivably, a strong central convection cell could set up a svvirling pattern with spokes. More speculatively, electromagnetíc forces might be Involved.

Similar and Related Phenomena. Marine light wheels (GLW4); the banded sky (GLA23); mag- netically alígned cirrus clouds (GWC3).

Examples of Cloud Spokes

XI. August 18, 1870. England. "A curious and I think important phenomenon to be in- vestigated is the apparent radiation of lu- minous streamers or linea of haze from distant thunderstorms. My attention was first drawn to this on August 18th, 1870, when after a very hot day, (88° in shade), an exceedingly violent thunderstorm tra- versed the western and midland counties of England. The sky was very clear here, but from the distant storm, lines of faintly lu- minous haze of extreme tenuity appeared to radíate, and retained their posltion for a very considerable time." <R1)

X2. November 1, 1937. English Cbannel. A pilot observes a large cumulus near the center of a shallow weather depression. "The mam body of the cloud with its anvil- like development is typical of a large cumulus cloud, but the radiating bands extending horizontally from the cloud base are remar- kable. A continuous layer of low cloud was observed farther east and ít is reasonable to suppose that the air at this level was al- most saturated, and so required little up- ward motion to produce condensation. One is tempted to visualize a wave motion cir-



Bands radiating from a cumulus cloud over the English Channel (X2)

culating round the cloud base although it is doubtful whether such an explanatíon would be dynamically acceptable. Judging from the diagram the bands might, however, be regarded as radiating from a poínt on the horizon rather than from the cloud base, in whicti case they would be parallel. The formation' might therefore have to be ex- plained as merely an illusion of perspec- tive." (R2)

References

RI. Ingall, Herbert; "Polarization of Haze, " English Mechanic, 18:262, 1873. (XI)
R2. "Curious Cloud Formation, '* Meteoro- lugu- al Magazint, 73:45, 1938. (X2)

GWC15 Great Excess of Ice Crystals in Cumulus Clouds

Description. Concentrations of ice crystals in the summits of slightly cooled cumulus clouds that are two to four magnitudes higher than the surrounding clear air.

Data Evaluation. Evidently a well-verified phenomenon. (Rl) Rating: 1.
Anomaly Evaluation. The discrepancy in ice-crystal concentrations infers that some un- known cloud process can multiply crystal concentration. This procesa is not understood but is probably well within the capaclty of today's cloud physics to explain. At least one promising process is at hand. See below. Rating: 3.

Possible Explanation. The author of Rl belleves that rimed ice pellets may shed ice splin- ters as the first step in a rather complex process of crystal generation. See Rl.

Similar and Relaled Phenomena. None.

Examples of Ice Crystal Excess in Cumulus Clouds

XI. General observatíon. "Perhaps the most puzzling observatíon in cloud physics reveáis that some slightly supercooled cura- ulous clouds, with summit temperatures only a few degrees below 0° C, contain high concentrations of ice crystals two to four orders of magnitude greater than the concentrations of ice nuclei measured in clear air at the same level. According to a series of careful and detailed aírcraft observations and measurements by Mossop and his col- leagues, sueh high concentrations of crystals occur only in aged cumulus that has been in existence for some time and acquired widths of several kilometres but are absent from newly rising cloud towers.....This large discrepancy between the concentrations of ice crystals and of ice nuclei suggeststhat some process of ice crystal multiplícation must be active in the cloud. " (Rl)

References

Rl. Masón, B. J. ; "Production of Ice Crystals in Slightly Supercooled Cumulus, " Nature, 245:451, 1973. (XI)

GWC16 Cloud Brightness Changes

Description. Certain clouds in aggregations of clouds exhibít marked changes in brightness. Data

Evaluation. A few observations of fair quality. Rating: 3.

Anomaly Evaluation. The nature of the anomaly ís not clear because the source of the brightness changes is unknown-----optical, electrical, or something else? However, since several possibilities exist (see below) this phenomenon is probably not especially mysteri- ous. Rating: 3.

Possible Explanations. The most likely sources of brightness changes are altered reflec- ting and/or refracting characteristics of ice crystals within the clouds in question. For example, aerodynamic and electrical forces may change crystal orientation and, of course, the movement of the cloud itself changes the sun-cloud-observer angles. Then/too, the ' brightness changes may be due to internal electrical action.

Similar and Related Phenomena. Dazzling lights on clouds (GLD15), luminous patches moving on cloud surfaces (GLD16).

Examples of Cloud Brightness Chances

XI. September 27, 1880. Sweden. "A singular phenomenon of clouds was observed on Sept. 27, last year, by M. Hildebrands- son, of Upsala Observatory. About 6.34 p.m. bands of círro-stratus extended N.E. to S. W.; they were moving slowly S. W. One of the bands, passing Auriga and Polaris, presented rapid changes of brightness. Some- times it disappeared almost completely, then it would become very distinct again. The band next to it to the S. E. presented the same fluctuations, but in less degree. It was not a mere subjective phenomenon, for another ob- server perceived the variations. The lumi-nous intensity sometimes remained constant a few minutes; then suddenly varied in a few seeonds. The alternations lasted half an hour. The phenomena, it is suggested, may have been due to variations of the electric charge of the cloud; they cannot, apparently, be attributed to variations of illumination by the sun, for the twilight was already faint, and no other clouds than the cirro-stratus appeared in the sky." (RI) These may have been noctilucent clouds. There is also a strong similarity to those daytime clouds that seem to become luminous auroral streamers at night (GLA12). (WRC)

X2. February 25, 1942. Malmesbury, Eng- land. "A curious cloud phenomenon never previously seen by the present writer was observed near Malmesbury' in Wiltshire on 1942 February 25 at 14 hours U. T., his attention at that tíme being directed to a patch of very high thin cloud about four de- grees in diameter which appeared to shine with a radiance nearly, if not quite, as bright as that of the sun, at the same time exhibiting various prismatic eolours, mainly yellow, palé orange and palé violet. The effect lasted at least four minutes and gradually faded away. The sun was shining brightly in a South-westerly direction at an altitude of approximately 25-30°... The curious thing about the luminous cloud... was that it did not appear in the same line of sight as the sun, but about 30° away in a westerly direction. Although there were other and similar clouds in the sky at the same time, none showed the same striking brilliance as the one here described, which was seen by at least four other persons... " (R2) The eolors may have been due to ir- ridescence.

References

RI. English Mechanic, 32:493, 1881. (XI) R2. Welsh, Henry; "A Cloud Phenomena," British Astronómica! Association, Journal, 52:115, 1942. (X2)

GWC17 Anomalous High*Altitude Haze Layers

Descriptlon. Strata of haze, usually undetected from the ground, found by instruments at altitudes above 15 miles.

Data Evaluation. Although only two recent articles discussing the detection of high-levelhazes by balloon-borne instruments have been found, it is claimed (RI) that 183 stratospheric clouds were recorded between 1870 and 1972, inferring that high-altitude hazes and clouds and rather common. (Obviously these very early reports were ground observations and may have in- cluded noctilucent clouds.) Nevertheless, we are probably safe in assuming that high-altitude hazes are well-attested. Rating: 1.

Anomaly Evaluation. The presence of haze above 15 miles ís classified as anomalous be- cause the sources are not known with any certainty. Also problems are the evident sta- bility and wide geographic dispersal of the haze layers. Rating: 2.

Possible Explanations. Particulate matter may be injected into high-levels of the strato- sphere by volcanic eruptions, meteors, and the solar wind.

Similar and Related Phenomena. Noctilucent clouds (GWC6), low-level hazes, bright night skies (GLA13), the white sky phenomenon (GWC1).

Examples of High-Altitude Hazes

XI. June 20, 1974. New México. Balloon- borne instruments reveal a large haze layer at 25 kilometers. (EI)

X2. February 5, 1982. Wyoming. Balloon experiments detected a 'mystery cloud' at 20 miles (32 kilometers). Author claims this is too high for volcanic ejec- ta (?). (R2)

Referenees

RI. Gibson, Frank W.; "A Rare Event in tbe Stratosphere, " Nature, 263:487, 1976. (XI)

R2. ”2d, Higher ’Mystery Cloud’ Found by Wyo. Scientists, " Baltimore Sun, March 12, 1982, p. A3. (X2)

GWC18 Anomalously Long and High Arctic Cloud Plumes

Description. The observation of unusually high and long cloud plumes over some Russian Arctic isiands (especially Bennett Island). Early on, it was suspected that these cloud plumes might have been the consequence of unannounced Soviet nuclear tests.

Data Evaluation. Large quantities of data carne from surveillance aircraft and satellites. Many articles appeared in the unclassified Science literature in the late 1980s and early 1990s. Rating: 1.

Anomaly Evaluation. After nuclear tests and seafloor releases of methane (from the decomposition of buried methane hydrate) had been eliminated, scientific opinión decided that the the cloud plumes were orographic; that is, natural lee clouds created by wind flowing across high Arctic ridges.

However, the ridges in the región are only about 2,500 feet high while the cloud plumes are up to 200 miles long and 6 miles high. The proposed cause and results seem dimensionally incompatible. It is also curious that such clouds are not seen elsewhere in the Arctic. Rating: 3.

Possible Explanations. Extreme examples of orographic clouds.

Similar and Related Phenomena. The 1984 "mystery cloud" (GWC22).

Enfries

X0. Introduction. During the 1980s, a series of plume-shaped clouds appeared over the Soviet Arctic. These clouds concerned scientists because of their unusual structure and iocation. They especially perturbed American military planners because the Coid War was in progrese, and the clouds looked much like those created by nuclear tests.

The first plume-eloud in this series to receive widespread public scrutiny was the "mystery cloud of April 8, 1984." This cloud looked so much like the consequence of a nuclear detonation that an F-4 Phantom aircraft was sent from Japan to investígate it. No nuclear debris was detected. See GWC22 for a fuller account of this particular cloud. (R12)

XI. The nature of the Arctic plume- clouds. Evidently the mystery cloud of 1984 mentioned above was only one in a long series of puzzling Arctic-cloud events. Some of these are now described:

> Large icy clouds, similar to plumes of gas that rise over volcanoes, have appeared over isiands along the coast of the Soviet Union during the past several years, baffling experts. who cannot explain what they are or what

causes thein.

The clouds dissipate in a few hours vanishing as mysteriously as they appear.

Among the plumes are a series of massive ciouds that during the past four years have periodically swelled over Novaya Zemlya, the Arctic island long used by the Soviets for nuclear weapons tests.

However, there appears to be no correlation between the clouds and known Soviet tests, which are usually detected by Western governments. Further, non-governmental scientists said the 200-mile-long plumes appear to be many times larger than the lar- gest conceivable nuclear explosión could produce.

In one incident, a NOAA satellite detected a large plume coming from the Arctic Ocean near Bennett Island, north of the Soviet Union, in 1983. Three distinct sources were found; one on the island and the other two about 9 miles off-shore on the ice-covered ocean. This plume was 6 miles wide. 155 miles long, and 23,000 feet high. (Rl)

An additional "unclassified" plume description appeared in 1988 in Eos, a weekly publication of the American Geo- physical Union.

This issue (R2) provided some amazing and at the same time unsettling photographs of these huge plume-clouds taken by satellites passing over Soviet Arctic islands. Eleven such events were tabulated from October 12, 1980, to June 12, 1986. Perhaps the most dra- matic event oceurred on March 12, 1982, over Novaya Zemlya. The picture shows a sharply etched tongue of coid vapor arcing some 175 kilometers at a máximum altitude of 9.5-10 kilometers. As with most of the plumes, movement of the vapor does not correspond to wind di- rection. Volcanic activity and natural methane gas releases are considered un- likely explanations. Since the islands involved are used for Soviet weapons tests, the plumes may be due to some incredibly energetic devices, although no radioactive releases or seismic activity seem correlated with the plume ap- pearance8. Ijueries to Soviet scientists went unanswered. (R2)

X2. Searching for a natura] explanation. F.C. Parmenter-Holt, a NOAA scientist, reacted to the descriptions and scientific discussions of the Soviet plume events as follows:

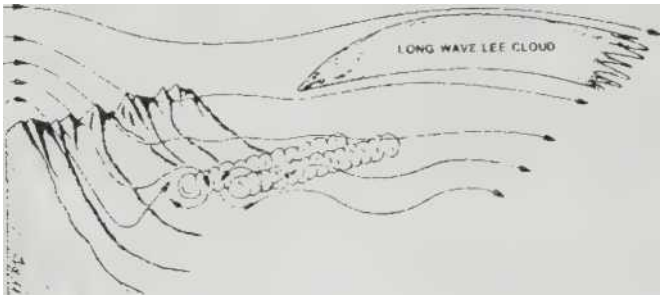
> I believe that these clouds are nat- urally occurring, orographically-in- duced formations. When winds blow perpendicular to the 2,500-plus foot glacial ridge, along the northern portion of the island, a long gravity- wave pattern is established downwind, on the lee side. The cases collected by Matson show sharp boundaries conforming to the contour of this glacial barrier. (R5)

Parmenter-Holt could well be correct in some cases, for wave-like orographic clouds often form in the lees of mountain ranges, such as the Roek- ies. Some of the plumes, however, ex- tend for 175 kilometers, as described above. This is pretty long for a low- altitude glacial ridge. Then. too, one should ínquire whether such plumes oceur near similar ridges in other northern dimes and not just over Soviet territory.

F.C. Parmenter-Holt opined above that the long plume-like clouds detected over Soviet territory were merely orographic clouds; that is, a consequence of the terrain below. Some facts presentad by W.O Roberts, in The Explorer, hardly square with that interpretation. For example, the March 12, 1982 plume seen over Novaya Zemlya was 109 miles long and at an altitude of about 6 miles. Its position did not conform to the wind direction at that altitude. Other plumes over Novaya Zemlya have been aligned with the wind, but they too have been at great altitudes. Said Roberts:

> Taken together the data suggest irregular emissions from a single point source near the north end of the Island as the cause of the myster- ious episodes.

Just what is being vented, if any- thing, remains unknown. No active voléanos are in this area, neither are there copious sources of natural gas. There have been no seismic ñor rudio- active indications of nuclear tests. (R6) By 1992, following the cessation of the Coid War, joint studies of the plume- clouds were being made by U.S. and



Schemaíic illustration of winds flowing over a mountain range creating long, plume-hke lee clouds. The long, high Arctic cloud plumes may be extreme examples of this phenomenon.

Russian scientific teams. Nuclear tests had long been ruled out. The possibility that methane gas was being released from the decomposition of sea-floor deposits of methane hydrate was also disposed of. Were the mysterious plumes just "odd clouds" after all? (R7)

The answer seems to be "yes." Air- eraft-based experiments over the Arctic islands seem to have confírmed that the plumes are truly orographic clouds created when airstreams pass over the low mountains of the Arctic islands.

The conundrum that remains is the anomalous heights of the plumes. Sometíales, the plumes reach heights of 3 kilometers above the rather low ridges that are supposed to cause them. (R9)

To our knowledge, this characteristic has not been explained.

References

Rl. Anonymous; "'Plumes' over Soviet Isles Continué to Baffle Experts," Las Vegas Sun, July 20, 1986. (Cr. T. Adams vía L. Farish) (XI)

R2. Anonymous; "Large Plume Events in the Soviet Arctic," Eos, 67:1372, 1986. (XI)

R3. Parmenter-Holt, Francés C.; "The Large Plumes of Novaya Zemlya," Eos. 68:1129. 1987.

R4. Weisburd, Stefi; "Cloud Conun- drums," Science News, 131:204, 1987. R5. Parmenter-Holt, Francés C,; "Plumes and Peaks," Science News, 131:403, 1987. (X2)

R6. Roberts, Walter Orr; "Mystery at Novaya Zemlya," The Explorer. 4:6, April 1988.

R7. Kerr, Richard A.; "U.S.-Russian Team Solves Arctic Mystery," Science, 257:35, 1992. (X2)

R8. Paull, Charles K., and Buelow, William J.; "Arctic Mystery: Plumes or Clouds," Science, 258:725, 1992. R9. Monastersky, R.; "Mountains Give Rise to Perplexing Plumes," Science News, 141:422, 1992. (X2)

RÍO. Fett, Robert W.; "Major Cloud Plumes in the Arctic and Their Rela- tion to Fronts and Ice Movement," Monthly Weather Review. 120:925. 1992.

Rll. Paull, Charles K., and Buelow, William J.; "Enigmatic Cloud Plumes," Science, 259:164, 1993.

R12. McKenna, Daniel L., and Walker, Daniel A.; "Mystery Plumes and Clouds over Soviet Territory," Science, 234:412. 1986. (XO)

GWC19 Atmospheric Rivers and Reservoirs

Description. The existence in the earth's atmosphere of vast quantities of water vapor in the form of river-like filaments and so-ealled "reservoirs." Ordinary, low-altitude clouds are not included here.

Data Evaiuation. Published observations are to be found in several science journals. (See references.) The primary data sources have been instruments earried aboard satellites, such as the Space Shuttle. Rating: 1.

Anomaly Evauation. The tropospheric rivers, sometimes cailed "Amazons in the sky," present two salient anomalies.

- The unknown forces that split the flow of tropical water vapor into rather- well-defined "rivers" when one would expect a homogeneous flow. Rating: 3.
- The origin of the "waves" in the tropospheric rivers. Rating: 3.
- The controverted origin of excess water vapor above 70 kilometers. Rating: 2.

Possible Explanation. The river-structure of water-vapor flow is probably created by atmospheric currents and circulation.

Similar and Related Phenomena. Hypothesized icy comets bombarding the earth's upper atmosphere (GWC20).

Entries

X0. Introduction. IVIost of our experience with water in the atmosphere occurs at ground level in the forms of precipita- tion and humidity. At higher altitudes, though, there are at least two important, very different manifestations of water vapor. In the troposphere, immense filaments-----virtual atmospheric "rivers" ----carry water vapor rising from the humid tropics north and south toward both poles. (XI) At much higher altitudes, 70 kilometers-plus, a región long believed to be very dry, scientists have recently discovered reservoirs of water vapor of unknown origin. (X2) Anomalies accompany both of these hydrological "8tructures."

XI. Rivers in the atmosphere. It has been long held by meteorologists that the water vapor rising from the warm, wet tropics waa earried north and south by more or leas continuous, homogeneous flows of moisture-íaden air. The study of modern water-vapor rnaps of the troposphere (roughly 10-20 kilometers alti- tudo), have disproven this simple model. Actually, the huge flows of water vnpor are split into several filamentary struc- tures resembling rivers.

These filaments are many times longer than they are wide, and deserve to be cailed "rivers." Some are 4,800 miles long and 420-480 miles wide. These aerial streams of water vapor develop in regular patterns and persist as they are transported through the troposphere. The huge quantity of water vapor earried by these aerial rivers make them worthy of note here. And they are also anomalous in at least two ways, which adds to their legitimacy in this catalog.

Especially remarkable is the atmospheric river that frequently flows south from Brazil to east of the Andes and thence southeast into the Atlantic.

A typical flow in this South American tropospheric river is very cióse to that in the Amazon (about 165 x 10^{fi} kg sec*). There are typically five rivers leading into the middle latitudes of the Southern Hemisphere and four or five leading into the Northern Hemisphere. The rivers persist for 10 days or more while being translated generally eastwards at speeds of 6 m sec . (RI)

While the sizes of these "Amazons in the sky" are impressive, we do not know why the water-vapor flow splita into about a dozen rather well-defined "rivera." To add to the puzzle, these atmospheric rivera have a curious wave- like struеture. (R2)

X2. Water-reservoirs in the upper atmo- sphere.

> It can't be true because it violates our ideas. (R4)

This was the collective opinión of many atmospheric scientists when a satellite experiment found approximately 50% more water vapor at an altitude of 75 kilo- meters than well-established theory pre- dícted. That was back in 1991. In 1996, a second satellite experiment of different design has confírmed the existence of this "excess" water vapor. Most geo- physicists are perplexed, to say the least.

Not L. Frank, though, because these experiments are in line with his theory that the upper atmosphere is continuous- ly pelted by house-size, fluffy, icy comets----Borne 20 each minute. Such comets could account for the excess water vapor at these altitudes. (GWC20) Frank asserts:

> When you get that excess of water vapor up there, it just can't come from the Earth. It must come from space. (R4)

Even so, other geophysicists are re- luctant to accept Frank's icy comets---------- that would be too much "crow" to eat!

One point levied against Frank's icy comets is that they would introduce more than three times the amount of water vapor actually measured. M. Sum- mers, a theoretician at the Naval Research Laboratory, summed up main- stream opinión:

> There's definitely something very un- usual going on in the mesosphere that we don't understand at all, but I'm not even cióse to saying this supports the small-eomet hypothesis. (R4)

By 2006, few scientists accepted L. Frank's icy-comet hypothesis. Neverthe- less the excess water-vapor still exists above 70 kilometers altitude, and we do not have a consensus theory.

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RI. Newell, Reginald E., et al; "Tropospheric Rivers: A Pilot Study," Geophysical Research Letters, 19; 2401, 1992. (XI)
R2. Anonymous; " Scientists Díscover Lengthy Rivers of Vapor in the Atmosphere," Baltimore Sun, January 22, 1993. (XI)
R3. Zhu, Yong, and Newell, Reginald E.; "Atmospheric Rivers and Bombs," Geophysical Research Letters, 21: 1999, 1994. (XI)
R4. Monastersky, R.; "Reservoir of Water Hides High above the Earth," Science News, 152:117, 1997. (X2)
R5. Anonymous; "Space Shower," New Scientist, p. 25, July 3, 1999 . (X2) R6. Kerr, Richard A.; "Rising Damp from Small Comets?" Science, 277: 1033, 1997. (X2)

GWC20 Black Spots on Ultraviolet Images of the Earth's Dayglow

Description. The appearance of black spots upon satellite images of the earth's dayglow in the ultraviolet portion of the spectrum. This phenomenon is intimately associated with the controversia! hypothesis that said spots are caused by the impact and vaporization of icy minicomets in the upper atmosphere.

Data Evaluation. The black-spot phenomenon has been observed repeatedly by different satellites. The black spots are generally accepted as real phenomenon, but most likely only instrument artifacts. It is the interpretation that they are the consequence of a rain of incoming icy mínicomets that is controversia!. We do not evalúate hypotheses. Black-spot rating: 1.

The ley Minicomet Hypothesis. The black spots seen in ultraviolet images of the earth's dayglow are due to clouds of water vapor in the upper atmosphere released by impacting house-sized, icy comets.

Some Implications of the Icy-Comet Hypothesis. If correct, the icy-comet hypothesis has some rather profound terrestrial and solar-system consequences. In the list of implications below, X-numbers refer to catalog entries that follow this introduction; R-numbers desígnate the many references at the end of this section.

- •Icy minicomets are and have long been an important source of ocean water (X1-X4, X6, X7, X10, R20)
- •Water vapor in the upper atmosphere derived from storms of impacting icy minicomets may be responsible for pluvial epísodes in the earth's history. (XI, R20)
- •Terrestrial cloudiness due to water vapor released from icy minicomets may have triggered the Ice Ages. (XI, R20)
- **•Impacting** minicomets **may** have carried prebiotic Chemicals and, possibly, actual **life** forms**. (X1-X3, R20)**
- •ley minicomets may be responsible for water/ice deposits on Mars, Mercury, the moon, and Saturn's rings.

Phenomena Possibly Related to the Icy-Comet Hypothesis.

- •Differences between isotope ratios of meteoric and ocean water. (X2, X5, X8, R20, R33)
- •Mierowave detection of upper-atmosphere water-vapor ''events" (trails, bursts). (X5, X7, X8, R20)
- •Terrestrial telescopic detection of minicomets. (X5, X8, Xll, X12, R20, R42, R44-R47)
- •Presence of excess terrestrial carbón. (X13)
- •Presence of unexpected quantities of water vapor in the upper atmosphere. (X5, X1U, X12, X13, R20, R59)

•Terrestrial radar detection of minicomets. (X7, X8, X12, X13) •Lack of comet-earried noble gases in terrestrial atmosphere. (Xll)

GWC20 SPOTS ON EARTH'S DAYGLOW

- •Lack of lunar seismic events attributable to impacts of icy cometa. (Xll, R6, R20)
- •Satellite instrument noise/artifacts. (X6, X13, X14, R20, R30, R35, R43, R52)
- •Satellite detection of bright trails of water debris in upper atmosphere due possibly to icy cometa. (X9, X14, R26)

Anomaly Evaluation. Tbe fundamental anomaly is the unexplained presence of black spots in images of the earth's ultraviolet airglow. Rating: 2.

Possible Explanations. Instrument noise/artifacts; vaporization of icy minicomets.

Similar and Related Phenomena. As listed above. Water rivers and reservoirs in the atmosphere (GWC19).

Entries

XO. Introduction. It is reasonable to ask why such an ostensibly astronomical phenomenon as "icy comets" is classified in this catalog under GEOPHYSICS and, in particular, is placed in the chapter on CLOUDS. Our rationale holds that the basic, defining phenomenon consista of the appearance of black spots (the "clouds") on satellite ultraviolet images of the earth's dayglow.

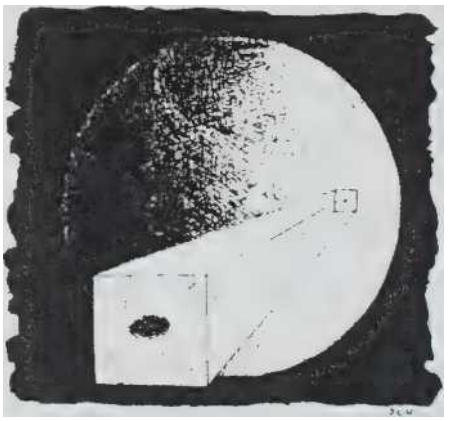
These small, ostensibly simple, black spots were sufficient to stimulate a decades-long controversy concerning their basic nature and, especially, their implications, chief of which are the fil- ling of the earth's oceans and the origin and transportation of prebiotic Chemicals and even life itself throughout the cosmos.

The lengthy controversy stems from the interpretación of the dayglow's black spots as clouds of water vapor released by small, icy comets that blot out tiny areas of the ultraviolet images of the dayglow.

It is truly amazing how a serendipi- tous, totally unexpected, apparently trivial observation could lead to a radical hypothesis with such wide and crucial implications. T.ike so many other paradigm-challenging observations, the dayglow black spots produced intense contention among scientists in astronomy, geology, geophysics, and biology. In this entry, we tie all these implications of the dayglow black spots and the resulting political milieu together.

The black spot/ice minieomet controversy epitomizes how mainstream Science deais with radical, disturbing hypotheses The controversy is replete with acrimony and claims of data suppression----------just as science has seen before in the debates over continental drift, coid fusión, etc.

Our newsletter Science Frontiers followed this saga íñ detail from 1985 to date. Our newsletter coverage of the icy-comets has been voluminous and relatively complete. We, therefore, draw heavily upon it, editing and adding supplementary information where needed. This is a reasonable approach because the saga is best apprcciated in a histori- cal context, such as provided by our timely newsletter.



Sketch of the earth's ***ultraviolet dayalow as recorded by*** *satellite DE-1. One of the anomalous black holes is shown enlartjed. (R20)*

This said, we now present thirteen newsletter Ítems in chronological order, edited and condensed where required. Access to specific subjects and anomalies is provided by the forgoing sections on Implications and Pertinent Phenomena, which here become indexes of sorts.

(Note that in the following pages, SF#xx refers to Science Frontiers newsletter number xx, and Rxx designates Reference xx at this section's end.)

A few pertinent observations and criticisms never appeared in the newsletter. Those we know about appear at the end of each entry as Supplementary Information and in entry X14. These are indexed and referenced in the same manner as the formal newsletter entries.

Each of the thirteen "X" entries that follows is tagged with tne newsletter number (SF#xx) and date.

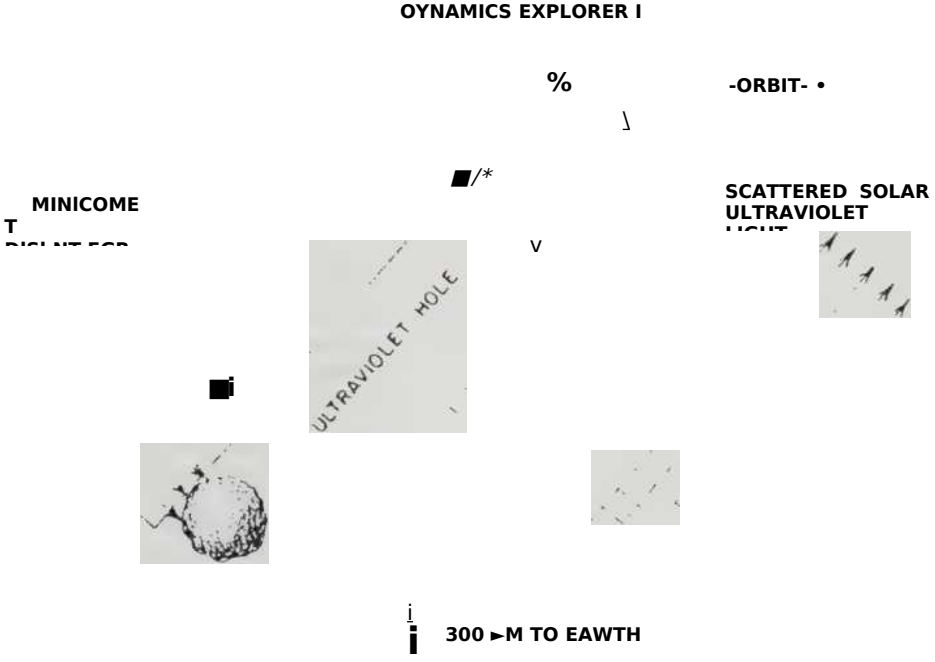
We do not claim completeness in relating this saga of Science.

XI. Atmospheric footprints of icy meteors. This newsletter appeared in SF|4i; 1985)

Serendipity triumphs again. From a day- glow experiment aboard NASA's satellite DE-1 (Dynamic Explorer-1) comes an unexpected discovery of considerable potential importance. Looking down on the earth, the DE-1 records the light emitted by atmospheric oxygen at alti- tudes of about 200-300 kilometers---------- this is the so-called "dayglow." The experimenters, L. Frank, J. Sigwarth, and J. Craven, all at the University of Iowa in Iowa City, have found that their dayglow images are speckled with transi- tory dark spots.

According to Sigwarth, each hole expands like a drop of dye spreading out in a glass of water; within about 30 seconds the dayglow intensity drops by about 95 percent over an area of about 3,000 square kilometers. Then, over the next 3.5 minutes, the dayglow intensity increases toward it8 normal valué as the hole grows to an area of about 25,000 km^. (RI)

The Iowa group thinks that the holes



(Left) ***Normal*** *hark-scattering of the ultraviolet part of sunlight. (Right) Hypothesized icy-comet debrís suppresses* ***ultraviolet*** *scotte> ing, leaving a black* ***spot*** *in the sateUíte's image of the earth's dayglow. (R 20)*

or spots are created by meteors hitting the upper atmosphere because the spots follow the same tíme distribution as meteors. For example, they are more frequent during the well-known meteor showers. The theory is that the dark spots are formed when íce associated with the meteors ís turned into water vapor, which reacts with the atmospher- ic oxygen producing the dayglow, in effect removing temporarily part of the light source. So far, everything seems relatively nonanomalous. But when quanti- ties are calculated, though, jaws begin to drop. The sizes of the spots imply that the average meteor involved weighs 10 kilograms, mostly ice and far larger than has been thought. In fact, they may be characterized as small icy eomets; that is, compositionally like the dirty snowballs that eomets are now thought to be, but much, much smaller. The impli- cation is that from 1,000 to 10,000 times more material is being added to the earth's atmosphere than previously believed ----------most of it being water. (RI)

From the pictures from this orbital launchpad, one's thoughts can really take off. How much water can this bombardment of icy meteors add to the earth, Mars, snd other solar system bodies?

It is known from the Greenland ice cores, that the extraterrestrial dust influx during the Ice Ages might have been as high as 3 x 10' tons per year.
If 10,000 times this amount of water is added to the atmosphere from icy eomets, we are approachíng 10^ tons of extraterrestrial water per year----------far from an inconsiderable amount. The effeets on the earth's climate could be large. If even greater fluxes of icy meteors were intercepted in the past, one might account for "pluvial episodes" on the planets. And, further, eomets now seem to transport "primordial organic sludge" around the solar system. The postulated icy eomets might then also be carriers of life forms or prebiotic Chemicals.

Supplementary information. The DE-1 was launched in August 1981. Later that year, Frank and his colleagues were already puzzling over curious black spots appearing on the ultraviolet dayglow images they were receiving from the satellite. The first formal announcement of the existence of the spots was pub- lished in the May 3, 1983, issue of Eos.
(H 6 0)

Considerable additional information on the DE-1, the black spots, and Frank's hypothesized icy eomets can be found in the book: The Big Splash, by L. Frank with P. Huyghe in 1990. (R20)

But the black-spot saga was far from over in 1990 when Frank's book was publíshed. Of especial concern was Frank's interpretation of the black spots and even the physical reality of the spots. The spots, some proposed, were simply instrument noise.

The Polar satellite was launched 15 years after DE-1 in 1996. It carried an experiment by G. Parks that also showed black holes in the ultraviolet dayglow images of the earth. Here was seeming vindication of Frank's DE-1 controver- sial discovery and, possibly, his icy niinieomet interpretation. (R26, R44, R47)

In 1998, R.A. Kerr wote in Science:

> Dismissed as instrument noise 10 years ago, the spots reappeared last year in images from a new satellite, Polar, persuading a few researchers
> that something peculiar--------although not a rain of eomets—is going on in the upper atmosphere. (R45)

Despite the Polar data, in 1998 it was still scientifically polítically incorrect to mention the icy minicomet hypothesis favorably in the Science journals, even though favorable data were in hand! There were still too many negatives, as we shall see in X2-X14.

X2. Oceans from space? (S#47, 1986)

In XI, we related how L.A. Frank et al, at the University of lowa, had deteeted dark spots on satellite images of the earth's dayglow. Frank thought that the spots might be due to clouds of water vapor released as small, icy eomets hit the atmosphere.

P. Huyghe has recently written more about Frank's discovery, Frank's hypothesis and its cool reception by the scientific community in the popular magazine Oceans. As Huyghe points out, there are several profound implications regarding the earth's history if Frank's interpretation of the black spots on the dayglow are on the mark.

> These eomets are not occasional visi- tors, he [Frank] says, like the one
> that comes by every 76 years and----------lueky for us--------never octunlly drops

in. No, these are very small, comet- like objects that enter our atmosphere at a rate of 20 per minute, he says. These comets, which he believes must contain about 100 tons of water apiece, vaporize on impact with the atruo- sphere and fall as rain or snow. Now that may seem like one sizeable coid shower, but on a yearly basis he says it'fi actually only a tiny fraction of the annual preciptation. Then again, over a span of 4.5 billion years, which is about how oíd the earth is, that's enough water, he
says-----trumpets blaring—-to créate the oceans. (R8)

Naturaily, such a theory is very dis- turbing because it runs counter to the widely accepted idea that the oceans were created by the outgassing of water vapor from the newly aecreteri earth.
As a consequence, Frank's satellite dota are readily accepted, but his radical explanation of them is not, as now noted.

That's as crazy as they come. (A noted astronomer)

...a case of Halley's fever. (One geologist)

...his interpretation is preposterous. (Fred Whipple, an authority on comets)

Critical as other scientists may be of Frank's theory, they have no other explanation for the dark spots on the earth's dayglow images. Furthermore, scientists are far from United about how the earth's oceans really did form.

Supporting L. Frank's hypothesis that icy minicomets might be the source of the earth’s oceans, in 1996 the European spocecraft Giotto obtained "Chemical footprints" of Halley's comet that closely matched those of seawater,
In this regard, L. Frank elaborated:

Analysis of the Giotto resulte carried out by Swiss physicist Petor Eberhardt and his colleagueB show that the earth's oceans contain the same retío of deuterium-to'hydrogen ns Halley’s Comet. The relativo concentrntions ot oxygen isotopes are also the same. And the smne is true for sulfur. Eberhardt believes that these fíndings are in ngreement with models proposing thnt the earth may have acquired its water and other volátiles from comets. (R20)

The Giotto results, however, have been challenged by measurements made by the James Clerk Maxwell submillimeter radio telescope on Hawaii. A study of comet Hale-Bopp showed a deuterium-to- hydrogen ratio twice that of seawater. Similar results have been announced by others for comets Halley and Hyakutake. (R33)

The radio telescope fíndings are ob- viously contradict those of Giotto.

More on this subject in X5 and X10. As serendipity would have it, Frank's theory also connects in an interesting fashion with origin-of-life speculations Frank remarks, in connection with the organic sludge supposedly present in comets:

These objects, because lhey are like a pistón of gas, can bring organic materia! down without burning it up like a meteor does. (R8)

X3, Small, icy comets and cosmic Gaia (SF#52, 198?)

L.A. Frank and his associates ot the University of lowa have speculated that the earth is continuously and copiously bombarded by small, icy comets. Not just a few now and then, but a steady rain so intense that over geological time some major geological consequences must ensue, (See XI.)

Some observers commented that surely these scientists have thrown nway their careers by suggesting something so ridiculous. But some suggestive data are
there-----in thr form of dark spots on satellite images of the earth's ultraviolet dayglow-----and late results continué to support this far-out interpretation. ridiculous or not, as now reported by L.A. Frank et al.

The mass of these objects is esti- mated ot about 10® gm each, and the total flux is about 10^ small comets per year. If this flux is repre«eritn- tive of the average flux over peo logic time, then the water ínflux is 8ufficient to fill the Earth's oceans. The fluxes of these objects are also large for all the planets outside the orbit of Earth. Considerations oí thermai stability imply that the fluxes of comets that impact Venus are con-

siderably less. The outer giant planets may be significantly heated relative to solar insolation by the small-comet impacts. For example, the total energy input due both to solar insolation and comet impacts may be similar for Uranus and Neptune. Thus it is possible that the temperatures of these two planets are similar, even though Neptune is farther from the Sun. (R9)

Comment ■ What has all this to do with "cosmic Gaia"? By "cosmic Gaia" we mean the cosmic versión of the conventional Gaia concept; i.e., earth-as-an-organism. The nnswer is that small icy comets can in principie transport throughout all of space:

- Immense quantities of water needed for life-as-we-know-it.
- The carbonaceous material basic to that same kind of life.
- The seeds of life, a la Hoyle and other proponents of panspermia.
- Energy, as discussed above by Frank et al. Observe that Frank et al are saying that the kinetic energy in the flux of small comets is suffi- cient to raise a plonet's temperatura as well as supply water.

Comment. In this light, exobiologists need not confine their search for extra- terrestrial life to planets surrounding warm suns. Somewhere, even fnr from stars, there may be places where comets may raise atmospheric temperatures to where life can prosper! Sunlight, of course, is not needed absolutely, as demonstrated by the profusión of life around deep-sea vents. (R9)

In fact, Frank and Huyghe devote an entire chapter in their book to the possible tranport of water to Mars and the outer planets. (R20)

X4. Oceans from Space (SF#56, 1988)

Although science-in-generai dismissed L. Frank's proposal that the earth's oceans may have been delivered by icy minicomets, (X2) Some astronomical data do not negate the idea of an exogenous origin of the oceans.

As theorized by L. Frank, comets secm to be the most likely candidates as extraterrestrial water sources.

C.F. Chyba has examined the lunar impnct record and derived an estímate of the total mass of objects impacting the moon during the (hypothetical) period of heavy bombardment 3.8 to 4.5 billion years ago. This allowed him to calcúlate the mass influx for the earth during this period. His conclusión: if only about 10% of the incoming mass consisted of comets (mostly ice), the earth would have acquired all its ocean water. (RIO)

Comment. Frank claims that the earth today ís continually bombarded by small icy comets, which down the eons may have kept the ocean basins full. In fact, we have two possible extraterrestrial
sources of oceans-------both of a cometary nature; that is, the massive comets such as Halley's and Frank's house-sized icy minicomets.

It wns only yesterday that the idea of ice surviving in the near-vacuum of outer space was ridiculed; few even dreamed that our oceans might be com- posed of space ice!

X5. One of the most astonishing dis- coveries of modern Science! (SF#58, 1988)

We take this título from P. Huyghe's receñí overview of the "oceans-from-space" controversy, printed not surprisingly in Oceans. (R8)) We have been follow- ing this debate for over two years.
Rather than retrace all the details, it is sufficient to say that the scientific community has been generally negative and dismissive about L.A. Frank's assertion and supporting evidence that each year some 10 million icy comets, each averaging sixty compact cars in weight, strike the earth's atmosphere, convert to water vapor and, in the full- ness of time, help fill the ocean basins.

In his article Huyghe reviews the considerable evidence that has accumu- lated supporting Frank's claim:

(1) The water in Halley's comet had the same abundances of two key isotopes as the earth's oceans;

(2) The rocket detection of unexpect- ed amounts of water vapor in the upper atmosphere;

(3) The microwave detection of unu sual water-vapor events in the upper atmosphere;

(4) The Lyman-alpha detection of hy- drogen concentrated near the earth; and

(5) The photographic detection of small, incoming objeets with the charac- teristics of the debated icy cometa. (R8)

Item 5 above has been reported in other publications:

> Using a telescope with a moving field of view------a difficult technique that required a year of preliminary calcu- lations to plan--------physicist Clayne Yeates has found and photographed what seems to be a population of fast- moving objeets near earth that rnnge between 8 and 16 feet in size. These previously undetected bodies match Frank's predictions concerning the speed, direction and number of pro- posed comets flying by earth, says Yeates, a scientist at the Jet Propulsión Laboratory in Pasadcna, Calif. (R16, R17)

Comment. Now all this does not mean that Frank’s liypothesis is proven in the eyes of all scientists. Far from it, there is too much at stake; namely, our whole view of the small-scale structure of the solar system and, even more im- portant, the heretical notion that the earth's oeeans have slowly filled with extraterrestrial water.

It has not been an easy two years for Frank. His reputation has been at risk. Huyghe hinted at this when he recorded Frank's reactions to the new photographic evidence. Frank commented:

> Looking at the data, seeing those streaks, has made a lot of people's hearts stop.

He is thrilled at this result, but he dreads what will follow.

> For the past two years 1 paid the price for being wrong. Now I '11 pay an equal price for being right. After all, you can't just tip the scientific world askew and expect everyone to cheer, (R8) ,

Supplementary information. Frank was overly optlmistíc about the positiva effeet Yeates' images ivould His findings were announced in two science magazines (R16, R17) but wero seemingly suppressed by most of the science jour- nal, which really count in deciding such controversial matters.

In The Big Splash, published in 1990, Frank and Huyghe went to the core of the rejeetion problem, which, to them, was more political than scientific:

> There was a war going on out there. We had to fight to get our papers published. We had to fight to let astronomers know that these objeets existed. If Yeates had gotten negative results his papers would have been aecepted fur publication within forty- eight hours and he would have been proclaimed a hero. That is the way the system works. But these findings were embarrassing. How could astronomers miss these things? So when the comets were seen through the telescope no one believed it. (R20)

Supplementary information. In 2001, L.A. Frank commissioned photoe to be taken from a ground-based telescope.
He employed a photographic expoaure routine designed to demónstrate that the black spots seen in the earth's ultra- violet dayglow are not just instrument noise.

> The telescope at the lowa Kobotie Observatory in Arizona used different exposure times to pick out genuine objeets from noise. The tciescope's camera took a 20-second **exposure,** waited 10 seconds and then took a further exposure of 10 seconds. Any object moving ncross the sky would produce one trail followed by a second trail half as long.
>
> Frank ciaims to have found nine comet traíls in the photographs. He says the objeets he detectod wero 50.000 kílumeters from the Earth and travelling at 10 kilometres per second, which agrees with his theoretical pre- dictions. (R52)

X6. Impact delivery of earlv oeeans (SF#68, 1990)----------

Where did the earth's oeeans come from? l’or deeade^ the stock nnswer has been: from the concfen68tion of vnpors escap ing iroiii the planet's cooling crust; that is. "outgassing." The possibility that some terrestrial water might have ar- rivo.i from extraterrestrial sources after

the earth's formation has been discount- ed. The major reason behind this ne- glect was the expectation that the ero- sive effects of large-scale impacts of water-carrying cometa and asteroids would preelude any net accumulation of volátiles, and could even reduce any exjsting inventories of surface water.

C.F. Chyba has rccently reexamined this question of cometary water influx vs. impact-eaused water losses using the latest estímales of comet/asteroid fluxes during the period between 4.5 and 3.5 billion years ago, when bom-bardment of the inner solar system was thought to be especialiy severe. Rather than the expected net loss, Chyba computes that the earth would really have gained more than 0.2 - 0.7 ocean masses ir> that billion-yenr period. Venus would have fared equally well, but Mars, more sensitivo to impact erosión, would have accreted ”only" a layer of water 10-100 meterá deep over the whole planet!
(This Martian water is now mostly below the surface supposedly.) (R23)

Comment. Not mentioned in this paper ís what might have happened after 3.5 billion years ago. The comet/asteroid flux did not drop suddenly to zero. In feot, there may still be some nc| influx of cometary extraterrestrial water, as suggested by L.A. Frank. lncidently, the work of Frank et al is not mentioned at al] in Chyba's article. Too controversia]?

X7. ley minicomets not so deed (SF872, 1990

An ítem in the June 1990 issue of Sci- entific American is entitled "Death Watch." in it. .1. Horgan plays dirges for four phenomena that have received considerable attention in Science Fron- tiere:

- •Minicomets;
- •Coid fusión;
- •Abiogenic oil; and
- •The fifth forcé.

Apporently Benveniste’s "infinite dilution" work hnd already been definitively ín- terred!

But wait, there is a microwave flick- *CT* of Ufe remaining in the minicomets.
J.J. Olivero and his colleagues at Penn State have been monitoring the sky with a microwave radiometer in their search for emiseions from high-altitude gases. During more than 500 days of observs- tions, they detected 111 sudden bur.sts of water vapor.

Olivero et al snggest that these bursts occur when email, icv comets vaporize at very high altitudes. These minicomets are of the same size (about 100 tons) and frequeney (20 per minute over the whole atmosphere) as those predicted by L.A. Frank. Frank's icy comets have been received with about as much warmth as "coid fusión." One reason for tbe unpopulority of icy comets is that they might have provided 8uffieient water to fill the ocean basins, thus undermining the accepted view that our oceans derived from outgassed water vapor from deep within the earth.

Besides this mindset, the minicomets do have some counts registered against them:

- •The effects of all the pur- ported water vapor on the ionosphere should be easily detected but they are not;
- •Seismometers emplaced on the moon have not detected their impacts there; and
- •Military surveíllance satellites have not seen these house- sized objeets. (R21, R22)

See fuller discussion by Frank and Huyghe in The Big Splash. (R20)

X8. Earth's water not imported. (SF#83, 1992)

That the earth is continuously bombarded by icy minicomets is unpopular in the Court of Science. F.ven less acceptable is the notion that over the eons these house-sized chunks of ice eontributed substantially to our planet's inventory of water.

In what will surely be hailed as the death knell of the icy comet theory is the diseovery by K. Muchlenbachs, of the University of Alberta. and F. Ro- bert and M Javoy, from the University oi París, that the water contained in the earth's rocks, both ancient and recent. is isotopicaliy different from the water found in meteorites. Meteoric water is assumed to be isotopicaliy the same as cometary water. Conclusión: comets could not have eontributed substantially to our planet's water inventory in thn geologicBl past. {Rᶜ !j

Comment. Of course, the isotopic measure- ments have to be weighed against all the data supporting the icy comet theory.

Also, no terrestrial laborntory has ever actually analyzed a pieee of cometary ice. In the above article, it is simply assumed that it would be similar to meteoric water.

'1 here have, however, been remóte Chemical assays of comete. See the Supplementary Information following |*2,* where two such remóte assays contradict one another.

X9. ley minicomets caught by a satellite camera? (SF#112, 1997)

A geophysicist really risks hie or her reputation if he or she suggeats that the earth is bombarded each minute by 20 house-size, icy minicomets. Well, L.A. Frank, University of lowa, did jusl that in 1985. He was duly pilloried for his trouble.

But, at the 1997 spring meeting of the American Geophysical Union, Frank presented new data to back up his pre- vious assertions. The most startling of his new evidence cante from a camera aboard a NASA satellite Time-lapse photos imaged two objeets streaking into the atmosphere over Poland and Germany. Frank identified these as clouds of water molecules from disrupted icy mini-comets. The clouds had expended from the house-size minicomets to clouds 3550 miles wide, weighing 20-40 tons each.

Frank thinks the minicomets come from a eloud of such objeets orbiting the sun from earth out to Júpiter and beyond. Why don't they evapórate in the sunlight and near-vacuum of outer space? Perhaps, thought Frank, they are protected by a thin coating of carbón. (R31, R32)

Supplementary jnformation. Refer back to X5, where C. Yeates reported tele- scopic observations of small, fast-moving objeets cióse to earth.

Yeates' data seem to have been suppreased in the mainstream science medía. However, Frank and Huyghe 8ssign two full chapters to it in their book The Big Splash. (R201

X10. It can't be true because it violetes our ideas! "(SFlilH.. 1997)

Such was the collective opinión of many atmospheric scientisto when a satellite experiment found approximately 50% more water vapor at an altitude of 75 kilo- meters than weli-established theory pre- dicted. That was back in 1991. Now. in 1997, a second satellite experiment of different design has confirmed the exis- tence of this "excess" water vapor.

Most geophysicists are perplexed, to say the least.

Not physieist L. Frank, though, becausa these water-vapor experimenta are in Une with his theory that the upper atmosphere is continuously pelted
by house-size, fluffy, icy coméis----------some 20 each minute.

Frank asserts:

> When you get that excess of water vapor up there, il just can't come from the Earth. 11 must come from space.

Even so, other physicists are re- luctant to accept Frank's icy comets— that would be too much "crow" to eat! One point levied against Frank's icy comets is that they would introduce more than three times the amount of water vapor actually measured. M. Sum- mers, *a* theuretician at the Naval Research Laboratory, summed up mainstream Opinión as follows:

> There's definítely something very un- usual going on in the mesosphere that we don't understand ut all, but l'm not even cióse to saying this supports the small-comet hypothesis.

References. For the forgoing article (R34, R39). The preceding section, GWC19, also deais with the subject, as does The Big Splash, by L.A. Frank aíded by P. Huyghe. (R20)

Xll. Broadside against small icy cometa (SF#118, 1998)

tn a late-1997 issue, Geophysical Research Letters published a group of fíve papera that detailed five different linea of evidence that are inconsistent with the elaim by L.A. Frank and J.B. Sigwarth that the earth is bombarded daily by 30,000 house-size icy cometa.

If such bombardment has really been oceurring, seientists would have to re- think the origins of the eorth's oceans. terrestrial life, and the formation of the solar system. No wonder the icy comet hypothesis is strongly chaMengedl

Three of the more interesting points made by thís group of papers are as follows (R36-R40):

(1) Our moon could not escape the icy-comet bombardm^nt. Roughly 1,000 craters 50 melera in diameter and spla- shes of debris 150 meterá in diameter rnust occur cach da£. There is no evj- dence that the moon is thus afflicted.

(2) Cometa also carry the noble gases argón, krypton, and xenón. These gases should accumulate in the atmosphere as the cometa disintegrate. The amounts
of these gases actually measured are 10,000 times less than those the postu- iaíed bombardment would produce.

(3) The icy comets should break up near the earth and produce clouds of ice crystals. Sunlight reflected from such 30-ton clouds would be brighter than Venus and easily visible before they disperse. Such objects are rarely seen. implying that small icy comets do not exist in the numbers elaimed.

Preceding this series of five papers is one by Frank and Sigwarth in which they describe their detection of atmnic oxvgen trails near earth These they attribute to small icy comets (R37)

Supplementary informatior., Of the above three criticisms, the first is the most serious. Scientists should detect visually or wíth their instruments sorne effects of the copious rain of icy comets on the moon.

In particular, the seismometers left beliínd by the Apollo astronauts should, one sopposes, register the impacts of house size icy comets. (R6, R25)

Frank counters this argument at great length in The Big Splash (R20) and elsewhere with the following basic argument.

> Frank says there is a mejor flaw in this argument- it assumes that mini- comets hit like rocks. and genérate seismic jolts capable of being de- tected by the Apollo instruments. 'Small comets are like fluffy snow- balls,' he objecta. 'lt is the seis-mometers lack of sensitivity to the impact of small comets that accounts For the discrepancy. (R20)

X12. No house-size snowballg (SF#125. 1999)

Beginning back in 1981, L.A Frank and his colleagues saw dark spots on satellite ultraviolet images of the eerth's dayglow. Frank interpreted the spots as huge splotches of water vapor createó by incoming house-size cometary snowballs.

Although some other data supported Frank's theory, nost scientists scoffed. After some mildl}' ncrimonious debate, a mainstream Science eonsensus deeided that the spots on the satellite photos were merely instrument artifacts.

Any lingering doubts as to Frank's house-size snowballs or "icy minicomets" impucting our atmosphere seetn to have now been dispelled definitively by a radar search by S. Knowles and his colleagues at the Naval Research Labora- tory. Using the Naval Space Surveillance Systern's powerful i-Rdar, their scens of the upper atmosphere detectad nothing resembling giant snowballs. (R55) Ac- cording to Frank's estimates of the flux of incoming minicomets, the radar should have seen 800-5,000 of them, (R48)

Comment. The radar search did not end the icy minicomet controversy. See XI3 following.

X13. lev Comets, Oceans, Life (SF#126, 1999)

Our thought, expressed in X12. that the icy-comet controversy might be winding down was premature. P.
Huyghe, coauthor with L. Frank of The fíig Splash, in response to SF#125 submitted three rccent articles from the Science literature. Two reply to major criticisms leveled against the icy-comet hypothesis; the third gives geologícal and geophysical reasons why there must have been icy comets or some other substantial influx of water and carbón to the earth's surface down the geo-logical eons.

No instrumental artifacts. The b8sis tor the 1985 claim of L. Frank et al that small, icy comets conttnually bom- barn the earth's upper atmosphere enme from photos takert far abov* the earth írom the Dynamics Explorer 1. Large, transient "heles" (really \váter vapor clouds) nppeared in the upper atmosphere. These were attributed to the wnter contnined in small, icy comets.

Most critics claimed instead that these "holes" were no more than instrumenta] errors. (R43) i.. A . Frank and J.B. Sigwnrth heve mvestigated this possi- bility and llave rejpcted it. (R51)

Navy radar search used incorrect cross sections. A more recent attack on the icy comets carne from S. Knowles et al. (X12) They claim that their search of the sky with the Naval Spnce Command Radar would surely have de- tected the icy comets if they exist.
Frank and Sigwarth respond that Knowles et al used radar cross sections that are feignificantly different from íhose typical of icy comets. It is likely that the Navy radar would not have been able to detect the comets. (R55)

Knowles et al repüed that the cross sections were accurate and that their conclusión standst (R57)

Too much water and carbón. Strong, Indirect evidence for the steady influx of icy comets comes from the geologists. They find that on and near the surface of the earth there is much more water and carbón than can be ascribed to the weathering of the earth's rocks.
For example. the amount of carbón tied up in rocks (carbonates, etc.) is 600 times that now found in the combined atmosphere, hydrosphere, and bio- sphere. Where díd all this extra carbón come fi'otn[7] The same questíon can be asked about the earth's water inventory.

Geologists have long assumed that this excess water and carbón come from the outgassing of voléanos. But recent quantitative estímales tell us that the volcanic sources are grossly inadequate. So are all other possible terrestrial sources. Therefore, some scientiste, such as D. Deming, University of Okla- homa, have been looking spaceward. Deming ventures that extrnterrestrial sources of water and carbón may be four or five orders of magnitude greater than auspected.

ÓbvlVusiy, a steady bombardnent of icy comets might fulfill Deming's re- quirements. Down the long eons of geological time, they could have fítled the oceans and showered all that excess carbón onto the planet's surface.

Deming ups the stakes in the icy- comet controversy when he links these fluffy snowballs to the well-known vaga ríes of life on earth.

The extraterrestrial influx rute may also act as the pacemaker oi terres- trial evolution, at times leading to mass extinctions through cIlmatic shifts induced by changas in accre- tion rales with concommitant disrup- tions of the carbón and nitrogen cycles. Life on earth may be balanced precariously between cosmic pro- cesses which deliver an intermittent stream of life-sustinning volátiles from the outer solar system or be- yond, and biological and tectonie procéseos which renove these same volátiles from the atmosphere by sequestering wate»* and carbón in the crust and mantle. (R50)

Comment. Need we mention the book Livíng Comets. by F. Hoy le and C. Wiekramasinghe? Why stop at water and carbón, when comets might also trans- port life or its building blocks? (See XI, X2, X3, R2D)

X14. Satelllte detectlon of bright trails of water-vapor debris in the upper atmosphere. (Not In newsletter, 1997)

In the May 30, 1997, issue of Science, Richard A. Kerr revíewed sorne of the evidence supportivc of the icy-coniet hypothesis. Kerr reported on a pheno- tnenon missing in our newsletter coverage.

Frank also presented observatlons of a new phenomenon high above the atmosphere that is presumnbly linked to atmospherie holes hnght trails of water debris. "1 just happened to be looking through the images," says Frank, "and all of a suelden saw these bright oxygen trails. We were shocked." About 10 times a day.
Frank concludes, an incoming small comet between 5000 and 50,000 kilo- meters leaves enough water in its wake that sunlight dislodges a trail of oxygen atoms from the water.

Frank's final line of evidence is visible light images showing hydroxyl, another fragment of water. These trails appear at altitudes of 2000 to 3000 kilometers, just above where small comets are supposed to disrupt to form atmospherie holes, and the trails seem to be about as abundant as atmospherie holes, say» Frank. "That's totally independent verifica- tion of the ultraviolet meesurements." he says. (R26)

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GWC21 Bizarre Clouds

Description, Clouds, or what seero to be clouds, that not only defy easy explanation, but also have an eerie, IJFO-like eharacter about them, including strange luminosity, curious shape, and weird motion. For the present, they are best described as bizarre.

Data Evaiuation. The subject observations are all aneedotal and, so far, each seen but once. The data come from newspapers or fringe journais. Ratíng: 3.

Anomaly Evaiuation. While they are bizarre, the clouds described below challenge no current meteorologicai paradigms and must be relegated to the "curiosity" file. They are outliers but nevertheless stiU must be cataloged. If verified by additional observations, they would certainly might become anomalous. Rating: 3.

Possible Explanations. None offered except, of course. bad observations.

Similar and Related Phenomena. Will-o'-the-wisps (GLN1); luminous aerial bubbles (GLD7); above-water marine phosphorescent displays (GLW3), All in our catalog Remarkable Luminous Phenomena.

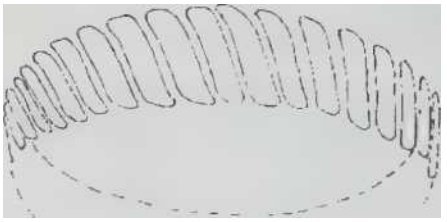
Entries

XI. July 24, 1996. Malborough, South Devon. Aboul midnight on this date,
E. Netley and his wife observed a most peculiar cloud formation. It was so well- formed and precisely organized that Netley felt that the term "cloud object" was appropriate. Lven so, he was con- fident that the apparition represented a natural phenomenon. "Natural" probably, but certainly the strangest cloud we have encountered in our more than 40 years of literature research.

The evening of July 23 was warm and a bit humid, with a modest breeze blow- ing in from the ocean. Netley and wife first saw the "cloud object" from n dis- tance of about a kilometer; they evcnt- ually walked to within 400 meters of the phenomenon. The "object" consisted of a slowly rotating ring of thin, vertically oriented clouds. (See figure.) The cloud ring was 80-100 meters across and seem- ed to rotate in a horizontal plañe at the rate of about one revolution per minute.

As thougb this were not strange enough, the rotating "cloud object" it- self moved in a larger circle 8-10 times the diameter of the "cloud object." The "cloud object" took 4-5 minutes to complete a trip around the larger circle.
The phenomenon lasted for about an hour before dissipating. (Rl)

We have here a remarkable, difficult- tu- helieve observation of a cloud that bears no resemblance to anything we have seen in the literature before. It is even stranger than many UFO reporte.



Sketch of the revolvmg "cloud object." (Part of the circle has been omitted for clarity.) Like a wheel-wíthin-a-wheei, the whole cloud formation moved en masse in a still

X2. Late May 1997. Taos VaJley, New México. A curious cloud hung over the Valley inducing many residents to cali emergency Services. Some thought it was smoke; others fog. However, no smoke was smelled, and conditions were not favorable for fog formation.

"<T. Fambro, who Uves Southwest of Taos, soid he went outside nt the time

of the "smoke¹' was reported ot about 8;30 p.m. ’1 couldn't even see the town from mv house...We had a 20-degree tempereture drop almost instantly.’"

The temperature returned to normal about 15 minutes later.

An automated weather station in Taos indicated that the cloud dropped visi- bilíty from seven to four miles. (R2)

K3. January 29, 2001. Avening, Glouces- tershire, England. Testimony of M.J. "McLaughlin as reported to the Journal of Meteorology by C. Roland.

"On Monday, January 29, 1 took a ride out Stroud way and decided to walk around Woodchester Park. It was a nice day and what better place to take advantage of the weather. I had not been {therel for a couple of years.

"Everything was going as normal until I got down into the park. 1 took the 'red’ path which takes yon right round the lakes. 1 had walked down to the oíd kennels when 1 saw what 1 can onlv describe a giowing fog. I thought it must be some sort of peculiar weather phenomenon. I carried on skir- ting the lake but the ’glow' WBS still there. I looked around for someone to confino this odd scene with me but 1 was alone. I must admit I began to feel a little unnerved by it. I quickened back; the glow could still be seen except it had drifted out over the lake. It was about six feet (two metres) high and thrce feet (one metre) wioe— although not a column. Indeed, at one point 1 almost thought it looked like a figure.

”1 have nevcr seen such a peculiar sight in all my days, and only wisli someone else had seen it, too."

It is the luminosity and small size of thís phenomenon that makes it so inte- resting. Could it have been a will- o’- the-wisp’* Or it might have been kin to the drifting, luminous "bubbles" de- scribed in GLD7 in our catalog Remark- able Luminous Phenomena?

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GWC22 The Mystery Cloud of April 9, 1984

Description. The appearance over the Western Pacific of a huge mushroom cloud with properties inconsistent with those of clouds accompanying nuclear detonations and any recognized meteorological phenomenon.

Data Evaluation. The 1984 mystery cloud was well-observed by three commercial aircraff and one military jet that was sent to investígate. Ampie descriptions of the event and the associated discussions appeared in the mainstream scjence journals. Th*-re are likely, however, to be unexamined classified reporta.
Rating- 1.

Anomoly Evaluation. AU rensonable sources of the mushroom cloud have been ruled out It remains a modest anomaly. Rating: 2.

Similar and Related Phenomena. Cloud plumes over Soviet Arctic islands during the same peno*! (GWC18).

Entries

XO. Introduction. The 1980s saw a huge, unexplained mushroom-shaped "mystery cloud" plus numerous curious cloud-like plumes appear in the Western Pacific. Both of these odd cloud vnrie- tie8 were of particular concern duríng the Coid War beeause they could signa! nuclear detonations—possibly of Soviet origin.

The large numbers of cloud-like plumea, which rose from Soviet Arctic islands, are sufficiently different from the single mushroom "mystery cloud" to be treated separatelv in GWC18.

In this section, we focua on the still-mysterious mushroom "mystery cloud' of April 9, 1984, which was also ob- served near the Soviet Arctic, but which was quite different in size and configura- tion from the suspicious cloud plumes of GWC18.

XI. April 9, 1984. Western Pacific Ocean. The crews of three airliners en route from Tokyo to Anchorage observad a gigantic mushroom cloud about 180 miles east of Japan. The cloud was moving rapidly up snd away from a cloud layer at 14,000 feet. It eventually reached a máximum altitude of about 60,000 feet, at which time its máximum diameter was about 200 miles. No fireball ñor flash was seen by anyone.

A nuclear explosión, possibly on a submarine was suspected. One pilot, suspecling a nuclear event, issued a Mayday alert and ordercd his crew to don oxygen masks. However, when on F-4 Phantorn dispatched from Japan arrived at the scene, it reportedly detected no abnormal levels of radio- activity. Wake Island hydrophones, to the southeast, detected some submarine volc8nic activity far south of the cloud, but no detonations in the area where the cloud was spotted. The distance of the volcante disturbantes and the pre- vailing winds ruled out volcanie sources of smoke. In the absence of nny hydro- phonic evidence, the authors concluded that the mysterious cloud carne either from a man-made atmospheric explosión (H huge one!) or some as yet unknown natural phenomenon. (RI)

A 1985 report in the New York Times amplified the Information about the mystery cloud recorded ebove.

"It WAS so cióse to cargo-laden Flight 36 of Japan Airlines that the plane's commander, Capt. Charles H. McDade swerved away from ít, began a rapid descent, ordered his erew to put on oxygen masks and radioed a 'May Day' distress cali.

i40'*E <je*f

First estímate of the location of the "mystery cloud" of April 9, 1984

r"Looks like a nuclear explosión, only there was no fireball,' he told flight eontrollers in Alaska. His plañe was slightly jostled. '1 turned tail and ren,' he said later

"The crews of KLM snd Flying Tiger airliners, also heading toward Alaska, saw the cloud, too. All were flying above a 14,000-foot cloud deck from which a bulb appeared, soaring at an estimeted 500 miles an hour. The bulb rapidly ex-pended to a diameter of 200 miles—-the distance between New York and Washington— then thinned and disappeared above 65.000 feet." (R3)

No light flash wns observed, although the cloud was reported to be slightlv luminous. Recourse to seismic records, microbarograph data, and reports from planes monitoring atmospheric radio- activity yielded nothing. Volcanlc erup- tions and a nuclear explosión seemed to be ruled out. The "mystery cloud" re-mained just that-------"mysterious"—at least publíeally!

To researchers A.C. Chang and J.A. Burnetti, a high-velocity meteor smash- ing into the cloud deck appeared to be a re a son a ble hypothesis. A meteor en- countering the cloud deck might hnve shattered into mnny fragmente, conveTt ing the moteor's kinetic energy into heat. The hot gas would then expand into a mushroom thapc, No Soviet activity would he involved, and everyone could

relax! (R2)

Meteors usually create vivid luminous phenomena when thev ínter the atmo- ephere, but none such were seen, To this date, we have not seen a consensúa seientific hypothesis on thf> origin oí this event. The truth may still be classified.

In 1986, D.L. McKenna and D.A. Walker presented further information on the mystery cloud based upon consulta- tons with the other pilote who had had good víews of the phenomenon, Their conclusión follows.

"Our conclusión is that the original esitmated positions were in error. Addi- tional data, primarily from Ven den Berg, place the event between the Kurils and Sakhalin. The altitude of the center of the halo at the máximum observed size is estimated to have been greater than 200 miles, and the diameter of the halo is estimated to have been Bt least 380 miles. It seems unlikely that a ground- based explosión could produce this kind of an effect. It is surprising to us that no offícial data have been provided by government agencies and that such a significant obeervations from a región of demonstrated military semsitivity was, and still remains, a mystery. <R4)

AHhough the modified position cf the mystery cloud places it closer to the area of Soviet nuclear testing, the size of the cloud amd the announced lack cf nuclear debrís seems to elimínate the nuclear-test hypothesis. Neither does the mystery cloud heve the characteris- tice of the cloud plumes described in GWC18 Therefore, the "mystery cloud" of April 9, 1984, remains anomalous— at least in the open literature!

References [*9]

Rl. Walker. Daniel A., et al; "Kaitoku Seamount and the Mystery Cloud of 9 April 1984," Science. 227:607, 1985. (XI)
R2. Chang, Andre C., and Burnetti, James A.; "Musbroom Cloud the Result of a Meteor?" Nature. 314: 676, 1985. (XI)
R3. Sullivan, Walter; "A Mushroom Cloud Remains Unexplained a Year after Sighting," New York Times, May 21, **1985.** (XI)
R4. McKenna, Daniel L., Hnd Walker, Daniel A.; "Mystery Cloud: Addition- al Observations," Science, 234:412, **1986.(XI)**

GWC23 Green Clouds

Description. Clouds and cloud-like entities that are green rather than the usual white, gray, yellow, black. etc. Green clouds are customarily rejected on sub- íective bases.

Data Evaluation. Two generically different green clouds are presented in XI and X2 below. The first is based on seientific observation; the second is anecdotal and. therefore. suspect. The data evaluations are the first figures given below.

Anomaly Evaluation. The obviously divergen! origins of the two clouds described in XI and X2 require sepárate attention:

- •Green thunderstorms in general (XI). Ratings: 1/3.
- •A green cloud with Ught rays observed in Soviet airspace (X2). Ratings: 3/1.

Possible Explanations. None offered.

Similar and Related Phenomena. The green flash at low sun altitudes (GEL1 in our catalog Rare Halos...); UFOs (XUO in a fortheoming catalog volume) .

Entries

XI. Occasional oceurrence. Wherever thunderstorms are prevalent.

Unlike the exceedingly strange green cloud de8cribed in X2 below. which seems to belong in the fringa literature, green thunderstorm clouds are of unchal- lenged meteorological origin. They retnain, however incompletely understood.

F.W. Gallagher. III, et al have below summarized the "green-thunderstorm" situation as of 1996.

Anecdotes abound that exceptionally severe thunderstorms may appear to emit an eerie, sickeningly yellow-green light. Skeptics scoff at this notion. The excited observers were deluded, or they made it all «p. This is, of course, the same knee-jerk response greeting UFO reports and accounts of many other anomalíes. Thunderstorms. however, do unquestionably have an objective exis- tence. And it actually turns out that a few storm-watching, professional meteoro- logiats have confirmed that greenish thunderstorms are real.

Such reliable testimony, however, is usually dismissed as due to the reflec- tion of greenish ground vegetation by the storm clouds or, perhapa, the effects of sheets of hail preceding the storms.

In 1995, F.W. Gallagher et al decided to settle the matter. They chased likely- looking thunderstorms nrmed with a spectrophotometer. Many storms later, they proved, fírst of all, that sume thunderstorms are definitely green. In fact, some gradually change from bJue to green tn the spaee of half an hour. Their ground observations, plus more spectrophotometer data taken from air- craft, refute the theory that the green color is from reflected vegetation. Hail may contribute to the green color but is not required. In sum, green thunderstorms reBUy do exist, but no one yet knows where all the green comes from. <R3)

X2. Late January 1985. From an aircraft 120 kilometers from Minsk enroute from Georgia to Tallinn, IJSSR,

The following anecdotal account should, perhapa, be relegated to our yet-to-be-pubÜBhed catalog on UFOs and like frowned-upon phenomena. However, in the first report collected, a green cloud is mentioned in a way suggesting a meteorológica] event, and we musí. therefore, not discard ít here. ¡t íB obvious, though, that tra*- firat report has led us down the garden path. But it is a fascinating and instructive excursión .

Our first report is an abbreviated and apparently well-expurgated versión of the subject event. It appeared in the Baltimore Sun on January 31, 1985. We quote it completely.

"An account of a mysterious 'green cloud' sending out powerful shafts of light and flying in tándem with an air- liner appeared in a Soviet newspaper today. The strange cloud was seen over Byelorussia by paBsengers and crew of a flight from Georgia to Tallinn, and by the crew of an airliner from Leningrad, passing 10 miles away according to Trud. Hikolai Zheltukhin, a corresponding member of the Academy of Sciences, said the object was certainly very big. He rejected the idea that the green cloud was an image caused by far-off atrno- spheric changes because the airman had flxed its location from the shafts of light it sent to the ground." (RI)

According the B. Maccabee, however, the complete story appeared in full in Russian publications as well as the New York Times and an AP dispatch. The whole story is totaUy at odds with the Sun's take on the event.

Below, Maccabee has summarized the larger story. Il is easily seen that much more than meteorology ís involved and that a strong UFO flavor intrudes.

Here is part of Maccabee's condensa- tion of this truly strange encounter.

"While flying at about 10 km at 4:10 A.M. about 120 km from Minsk, the co- pilot first noticed a bríght yeliow spot off to the right and above the plañe, like 'a static large star'. Suddenly a thin ray of light carne out of it and fell directly down to the earth. The ray suddenly spread into a eone of light.
From this point on the whole crew wit- nessed the events. Then a second cone appeared which was wider and less powerful than the first one, and finallv, the third—wide and quite bright. The crew members had the impression that the bright 'star' was 40-50 km above the earth. The copilot began to make a sketch of the phenomenon. The surpri- sing thing about tlieae beams of light was that 'Everything.. .houses and roads ...was seen clearly at the section of the earth sur face lit by the cónica] beam.' Then the beam rose upward from the

earth and hit the plañe. The pilote ssw 'an extremely bríght white spot surround- ed by concentric color circlee. The white spot flashed and a green cloud appeared in ils place. The object then appeared to move loward the plañe at a rapid rate, Crossing the plane's route

"At this tíme the navjgator called Minsk to report the sighting. Just as he reported, Ihe object etopped moving The green cloud then dropped, Crossing the airplane's altitude and 'then swept vertically upwards to settle at an alti- tude of 10,000 m, exactly on a level with the aircraft where, as one of the pilots remarked it remained to accom panv it. as if it were an escort. to the end of the flight.' The flight speed was 800 km/hr. There appeared to be hlink- tng lights within the cloud." (R2)

One can aee in all this how edítoríaí changes can completely alter the nature of an anécdota) event. Where the truth lies is unknown.

References

Rl. Anonymous; "Mysterious 'Green Cloud" Appears near Airliner," Baltimore Sun, January 31, 1985. (X2>

R2. Maccahee, Bruce; personal comrmini- cation, March 12, 1985. (X2)

R3. GaJlagher. Frank W. , 111, et al; "Green Thunderstorms Observed," American Meteorological Soclety, Bulletin, 77:2889. 1996. (XI)

GWC24 Exotic-Chemical Clouds

Description. Ephemeral, sometimes seasonal, clouds containing concentrations of exotic Chemicals much higher than those in the standard atmosphere. Widespread, unidentifiable odors are included in this category.

Data Evaluation. Concentrations of **Chemicals,** such as **sodium** and bromine, are detected by scientifíc instruments. They are usually reported in the scientific journals. Widespread, strong odors—offensive or pleasant—are noticed by the general populace and are generally ignored by Science publications, even though they can **be** very puzzling. Both cetegories of olfactory phenomena are weil- established. Rating: 1.

Anomaly Evaluation. Industrial sources of Chemicals and odors are usually quickly located and abated. Natural sources----------wide-area plant emissions, meteor disinte- gration-----are more elusive. Some of these sources are never discovered (X3, X4); others remain controversia! (XI. X2). Generally speaking, exotic olfactory clouds are very weakly anomalous; curious rather than paradigm-threatening. Rating: 3.

Similar and Related Phenomena. Smoke from distant conflagrations (GWR2); large-scale lake turnovers (ESC6 in Anomalies in Geoiogy) ; volcanic gases.

Entries

XI. Spring. The Arctic. "Unusually high levels of bromine gas and partióles detected in Arctic air samples by ground- based instrumenta have focussed scien- tifie attention on this heretofore little- studied trace gas. Measurements from 1976 to 1980 show that during the three- month Arctic spring. vast pulses of bromine enter the atmosphere, During these pulses, scientists report, levels of bromine over the Arctic are at least 10 times those found elsewhere ín the world." (RI)

Although the notorious Arctic haze also increases in the spring. it is not deemed an important source of the bromine pulses. Rather, it is speculated that marine organisms that bloom in the Arctic spring are the chief producers of the bromine.

X2. Unknown frequeney of occurrence. Areal extent undetermined. "Clouds of sodium etoms that rapidly appear and then disappear have been detected high in the sky over Urbana, 1)1. While it may seem strange that the vanishing clouds have been noticed only over that city, the scientists from the University of Illinois who observed the phenomenon say that they are not really perplexed, because they have the only machine that can detect the sodium clouds, which are probably coming from meteors as they burn up in the atmosphere." (R2)

T. Beatty and colleagues at the Üni- versity of Illinois direct lidar (láser infrared radar) beams vertically into the upper atmosphere causing atoms there to emit characteristic radiation. This is detected back on the ground by a sensitivo tolescope and spectroscope. As of 1988, Beatty's group has detected at least fíve sudden surges in wavelengths characteristic of sodium atoms located at altitudes around 85 kilometers.

If these sodium bursts are produced by disintegrating meteors, they must certainly occur elsewhere.

X3. Frequent occurrence. Bartlesville. Oklahoma. "A scent squad has been unleashed in Bartlesville, Okla., to trace and identify an elusive odor that has plagued residente for months. The 19-member Bartlesville Odor Mitigation Task Forcé will distribute about ʜ half dozen devices to trap the smell, which will then be sniffed and characterized by traíned noses at a Chicago research eompany- The city has received 60 calis this year about the odor, described as srnelling like rotten eggs or butane, but they have been unable to determine the source." (R3)

So far, no announcemerit that the source of the Bartlesville stench has been found has reached us.

Stenches sueh as that afflicting the residents of Bartlesville are invisible clouds of Chemicals and, therefore, deserve a place in this catalog under GWC. If their source---usual!y found to be a manuffleturing plant, a dump, farmers' manured fields, decaying swamp vegeta- tion, Chínese chestnut trees in bloom, etc»-—cannot be found, we do have an olfactory anomaly. Usualiy, howev.er, the odoriferous sources are found or, as in X4 next, they just disappear and remain unknown.

Such olfactory clouds---------mostly offeu- sive but occasionally pleasant----------ar^ very common. We take space to catalog Just two that happened to cross our désk (X3, X4)

X4. October 27, 2005. New York City. "On the evening of 27 October, the sticky-sweet smell of maple syrup washed over much of New York- It was first detected around 8 pm in Lower Manhattan but spread rapidly to the Upper East Side, Prospect Heights in Brooklyn and parts of Staten Island. Borne thought it smelled more like caramel or freshly baked pie- The aroma sparked hundreds of calis to the city's 311 emergeney hot line-----was it a terrorist gas attnck de- viously cloaked in the smell of grand- ma's kitchen?" (R5)

The odor in this case was harmless and dissipated quickly. The source, though, remains a mystery. Given the eize of the area affected and the eon- sternation it evoked, something larger than a bakery must have been involved!

X5. Frequent feafure. Southern Hemi- sphere troposphere. In 1990, NASA Batellites first revealed strong concen- trations of ozone in the troposphere over South America and Africa. These huge, invisible clouds tend to form over largely uninhabited parts of these land masses at various times of the year. Complex air cúrrenla over South America transport some of the ozone out over the Atlantic. The African ozone clouds drift

toward Australia.

The sources of the ozone clouds are probably tires (from slash-and-burn agriculture) in the forests of Amazonia and natural and artificial fires in Africa's vast savanna grasslands.

The current thinking is tliat gases from these burning biomasses, such as nitric oxide and nitrous oxide, react with tropospheric oxygen to create the ozone. (R4)

References

R1 Simón, C,; "Sources Sought for Arctic Bromine Pulses." Science News. 124:151, 1983. (XI)

R2. Raloff, Janet; "Sudden Sodium Surges Seen over Illinois.." Science News, 134:238, 1988. (X2) *

R3. Newrnan, Steve; "Malodorous Mys- tery." Baltimore Sun, July 22, 1990. <X3)

R4. Anonymous; "Puzzle of Mystery Ozone Cloud over Brazil," New Sci- entist, p. 6, October 10, 1992. (X5) R5. Anonymous; "Sweet Smell nf' Mystery," Portean Times. #205:21, Janu- ery 2006. Source cited: New York Times. (X4)

GWC25 Layers of Unidentified Material, Not of Natural Origin, in the High Atmosphere

Deseription. The existence of layers of unidentified material, not of natural origin, in the upper atmosphere.

Data Evaluation. Dust lavers ir the upper atmosphere have been detectad by satellites, aircraft. and terresmai radars. The specific experiment described $b_e$low employed láser radar. The results were reported in Nature. We have not noticed confirmations as yet. Rating: 2.

Anomalv Evaluation. Most Ükely, this unidentified, unnatural material is human pollution of some sort. Its nature. origin, and mode of transportaron were not known as of 1985. Rating: 3.

Similar and Related Phenomena. ley minicomets (GWC20); nebulous meteors (AY08), interplanetary dust (AZO); both in The Sun and Solar System Debris.

Entries

XO Introduetion. The upper atmosphere is populated by severa! extensive, sliift- ing layers of dust and other materiols. Observntions from satellites, aircraft, balloons. and ground-based radBr have detecled dust layers in the low*>r meso- spherc and upper stratospherí These layers may be a few kilometers thick, hundreds oí kilometers in extent, and reach to over 59 kiiometers altitude. Many scientists attribute the dust to disintegroting meteors. (Rl)

XI. in 1984, L. Thomas et al reported a layer of unidentified material that appeared to not be of natural origin; that is, probably human pollution of some sort. Here is the abstract of their paper in Nature.

> In this letter wc report the results of láser radar measurements at Abery- stwyth (52°25' N, 4°04' W) which re- vealed the presence of a discrete layer of atmospheric material of about 0.5 km thickness near 40 km for at least 3 h during the night of 4-5 July 1983. Wind data indícate that it was moving from the east and has an east-west extent of at least 170 km.
> Wc estímate that the layer has » mass content in excess of 100 kg for each degree of latitude width. The layer does not appear ti* be due to a natural terrestrial source or extra- terrestríel material, and ít seems likely that it was a result of pollution at upper atmospheric heights. (Rl)

If not a "natural" material, we are left with a human source of some sort that emits pollution of still unknown composition that is somehow carried to 40 km. Just what this material is, what its origin could be, and hmv it gol to sueh high altitudes reraain a mysteries.

Reference

Rl. Thomas, L., e: oí; "Observations of a Thin Layer of Material in the Upper Atmosphere," Nature, 312:627, 1984 (X0, XI)

GWC26 Artificial Polarity Inversión of Thunderclouds

Description, The artificial reversal of charge distribution on thunderclouds from the normal negativa bottoms and positive tops to positive bottoms and negative tops.

Data Evaluation. Only u single pertinent experiment is in our files at present.
This experiment is suggestive only and over two decades oíd. There may be later, more definitive data. Rating: 3.

Anomaly Evaluation. The artificial inversión of thundercloud polarity would demónstrate that externa] conditions, such as electrically charged mountain peaks, can greatly modify the thunderstorm engine. In 1984, this possibilitv was widely ' questioned. The experiment deseribed below (XI) and later ones may help change entrenched opinions. Rating: 3.

Similar and Related Phenomena, S. Lemstrom's 1881-1882 experiments attempting to create artificia] auroras (GLA6); auroras correlated with thunderstorros (GLA9) both in our catalog Remarkable Luminous Phenomena.

Entries

X0. General observations. The great majority of thunderclouds are negatively charged on their bottoms and positive on top. In nature thnderelouds with reversed polarity are rare. Contrary to normal thunderclouds, they produce positive rather than negative lightning bolts.

XI. 1984. New México. C.B. Moore and eoworkers at the New México Institute of Mining and Technology, at Socorro, tried to induce polarity reversal in passing thunderclouds by injecting negative ions ínto the atmosphere. They selected New Mexico's Magdalena Mountain 8 where summer thunderclouds ore frequent. Moore ct al strung a 2-kilo-

meter wire neross a deep canyon and applied - 100 kílovolts to it. The wire as-a-whole emitted a negative current of 300 microamperes into the air.

Üut of about 65 clouds that roamed the canyon. the group observed two clear-cul cases of thunderclouds with inverted polarity; negative on top and positive on bottom. These clouds are also thought to have expelled positive charges via lightning. (Rl)

It is possible that the negatively charged wire stretched aeróse the canyon did indeed induce polarity reversal ín normal passing thunderclouds, but it is also possible that the two reversed- polarity clouds that werr observed acquired their polarity naturally, al- though "how" and "where" are unknown.

The charged-wire experiment is suggestive though. More experiments are planned using a larger power source. Besides polarity inversión, externa! amplifieetion of thunderclouds may be possible.

Relerence

Rl. Weisburd, Stefi; "Making Upside- Down Thunderclouds," Science News, 126:306, 1984, (Xl)

GWC27 Cloudiness Correlated with Cosmic Ray Intensity

Description. The positive correlation of]ow-altitude cloudiness with the cosmic - ray flux reaching the earth's atmosphere.

Data Evaluatíon. The Science literature contains severa! positive correlations that demónstrate this phenomenon. (See bibliographv in R2.1 Rating: 2.

Anotnaly Evaluation. These positive correlations are difficult-to-explain because the total energy content of the cosmic ray flux is only one-billionth that of solar irradiation. The eléctrica] charges on cosmic-ray partióles must somehów stimulate cloud-forming processes that gTeatly exceed their energy contribution. This "raierophysics" is still not well-understood. Rating: 3

Similar and Related Phenomena. The cascade effect by which cosmic rays trigger the formation of lightning.

Entries

X0. Introduction. For well over a century, scientists have been debating the influence of sunspots upon terres- trial weather. Skeptics ridiculed the practice as "sunspottery." It is true that solar irradiance dees vary with the solar eyele (charncterized by sun- spot numbtrs), but terrestrial solar irradiance varíes oply 0.1% on a decadal scale. (R2) This is too small to have significant effeets on the earth's cloudiness .

On the other hand, the combined intensities of cosmic rays from Üie aun and galaxy vary about 15% over the solar eyele. This variability arises from the changes in the solar wind acting upon the earth's magnetosphere, which is the earth's shield ogainst the cosmic-ray flux. Cosmic rays reaehing terrestrial cloud levels thus lio ve o variability that one can compare with the ever-changing cloud cover. However, the energy input to the earth's atmosphere from all cosmic rays is only about that of stnrlight. It would setrn on the surface that cosmio

rays luck the energy to have much effect upon cloudiness.

Nevertheless, in 1997, H. Svensmark and E. Fris-Christensen reported *a cor-* relation between the earth's cloud cover and cosmic-ray intensity. (RI)

Another positive correlation by N. Marsh and H. Svensmark appeared in 2000 in Physicai Review Letters, 85:5004. This study)s summarized below in XI by G. Chin.

XI. The Marsh-Svensmerk correlation,

Marsh and Svensmark have measured global average monthly cloud anoma- lies for lower, middle, and uppcr ti'Oposphere, and correlated them with changes in the cosmic-ray flux. They found, surprisingly, that cloud cover at altitudes of less than 3.2 kilo- meters covaries with cosmic-ray fluxes from 1980 to 1995, but no correlations was seen for higher alti- tude cloud.s . (RI >

X2. How can cosmic rays affcet cloudiness? As poinled out in X0, the energy contení of cosmic rays reaching low altitudes is very weak only one billionth
that of sunlight--------although much more variable than solar irradiance. How can such *o* relatively weak flux alter cloud cover? Actually, meteorologists do not yet understand the "microphysics" oceur- ring between the electrically charged cosmic-rays snd atmospheric aerosols. K.S. Carslaw et el have examined severa! physicai processes involving cosmic rays that might contribute to cloudiness, such as a rather complex "ion-aerosol clear-air[1]' mechanism.

As of 2002, however, cosrnic-ray-forced, cloud-forming mechanisms are not well-understood.
(X2)

References

RI. Chin, Gilbert. ed.; "Low Clouds and Cosmic Raya," Science, 290:2033, 2000. (XI)
R2. Carslaw, K.S., et al; "Cosmic Rays, Clouds, and Climate," Science, 298:
1732, 2002. (X0, X2)

GWC28 A Curious Ribbon Cloud

Ocscription . A suddenly-appearmg. íow-altitude, horizon-to-honzon, nbbon-üke cloud that could not be attributed to an aircraft's condensation traíl (contrail).

Data Evaluation. The ribbon cloud was observed visually and with optical Instruments by the officers and crew of n merchant vessel. The crucial cloud-aitítude measurements are díffícult-to-make from a single observation point Rating: 3.

Anomaly Evaluation. The cloud observers were adamant that ít could not have been made by an aircraft. A low-level meteor or piece of spacecraft debris also seem unlíkely by virtue of theír unmistakable lumínous effects and sounds. Assuming the accuracy of the observations reported below, the ribbon cloud re- mains a mystery. Rating: 3.

Possible Explanation. Observer errors and misjudgments *as* to cloud altituoe and dimensions.

Similar and Related Phenomena. The sky-spsnning auroral arch (GLA2 in our Remarkable Luminous Phenomena.

Entry

XI. November 18, 1999. North Atlantic Ocean. Aboard the m.v. Waterford en- route from Pto Bolívar, Columbia, to Ijmuiden.

"At 1832 UTC an azimuth of Júpiter was taken shortly after sunset. The sky in the vieinity of Júpiter was completely clear» no eloud of any type. with bul a few small cumulus dotted nround the horizon.

"About five minutes later, having completed the calculations, the observer again looked out to see a ribbon type eloud, broken in formation, stretehing almost from [the] eastern horizon to [the] western horizon. If the estimated height (see below) ia reasonably correet, then the bandwidth couldn't have been more than a few hundred feet, apparent- 3y more cigar-shaped in cross section than fíat, the máximum axis being horizontal, the mínimum vertical. The eloud wa.s fairly consisten t in density, and at a tairly stable nltitude, not undulating or rippled, having the consistency of a small cumulus eloud (white and fleeey), but also translucent.

"Initiallv, it was thought to be a condensation trail, but this was shortly dismissed as it was considered too low (estimated to be less than 10,000 ft altitude, probably around 7,000-8.000 ft). Both ende of the eloud were checked with binoculars but no aircraft was evi- dent; however, as a yardstick, and by good fortune, one díd appear nround 1910, presumed to be at the usual 30,000 or so feet, heading west-south-west- ward." (RI)

If not a condensation trail, the next best guess would be a meteor trail, al- though the altitude is also very low for one. But a bolide ntreaking across the sky a? such a low altitude at night would have created a spectacular lumi- nous display and probably considerable sound as well. Neither occurred.

Reference

RI. Bennett, Paul; "Ribbons in the Skv," Marine Observer. 70 177, 2000. (XI)

GWD DARK DAYS, FOGS, AND OTHER OBSCURATIONS

Key to Phenomena

GWDO Introductíon
GWD1 Dark Days and Obscurations ot the Sun GWD2 Pogonips and Olher Ice Fogs
GWD3 Mists and Epldemics GWD4 Dry Fogs and Dust Fogs

GWDO Introductíon

A dark day is not merely the veiling of the suri by ordinary clouds---------they at least let through enough light to conduct the busíness of the world. On a dark day the pall of darkest night descends suddenly, chickens go to roost, and men and women pray and grope for candles, although not necessarily Ln this order. New England's famous Dark Day of 17S0 is typical of the genre.

The standard explanation of the dark day is smoke írom forest fires in the hinterlands or per- haps some unrecorded volcanic eruption. These are reasonable surmises because many dark days are accompanied by black rain that is thick with soot and ashes. Wlnd, goes the theory, earríes these combustión products hundreds of miles from their origin and blots out the sun in the procesa. Sometimes, though. the darkness seems irrational.descending suddenly without the approach of ominous dark clouds. Not infrequently, forest fires com- mensurate in size with the dark day are never found. In America, they were "out west"
somewhere----set by the Indians. This sufficed in the pioneer tiays when the foreste of an entire State could be consumed without New Englanders ever hearing about it. While ad- mitting that forest fires are very líkely the cause of most dark days, we should not ignore the fact that some scientists have proposed that some forest-fire-less dark days might have been due to cornet tails or cosmic matter obscuring the sun.

Superfícially, fogs and mists would seem to present little grist for the anomaly mili. But diligent research among the older journals brings to light the supposedly deadly ice fogs, the pogonips, the curious association of "blue mists" and cholera outbreaks, and certainly not least the near-global, self-luminous dry fogs of 1783 and 1831, when one could read out-of-doors at midnight on the highest mountain and in the deepest valley.

GWD1 Dark Days and Obscuratíons of the Sun

Dcscription. Periods svhen abnormal darkness descends upon a región. The sun may be obscured or weakened for anywhere from a few minutes to severa! days. In some instances, the stars may be visible; in most cases the entire sky is darkened. Many dark days are accompanied by yellowish clouds and black precipitation, signifying considerable particulate matter in the atmosphere. The areas afflicted may be just a few square miles or continent-sized.

Background. Dark days and solar obscurations are some of the oldest recorded anomalies of nature, beginning even before the strange darkness of the crucifixión. Many of the oíd tales are indeed mysterious, but only because of distortions and poor observation. Most modern dark days are found to have easily explained origins. Since there are several possible origins, this is a composite category lumping weather, incendiary, votcanic, and astronomical events into one class.

Data Evaluation. Dark days gnd solar obscurations have occurred throughout historical tirre.s. Oíd reports are vague but those of the last century are good. Rating: 1.

Anomaly Evaluation. The reduction of sunlight by smoke, volcanic ash, or menacing clouds can only be considered as curious. But if, during normal daylight hours, the sunlight fails and the stars are seen, common terrestrial obscuring agents can be ruled out, and a significan! anomaly exists. An anomaly may also exíst if the area afflicted by smoky and/ordust blankets is not commensurate with possible sources; viz. , forest fires, volcanic eruptions, etc. Of course, one can always malntain, even today, that dark days are due to some distant, unrecognizeu source. A century ago, dark days. often as not, were blamed on Indians burning the prairies somewhere "out west. ” Generally, dark days will have prosaic explanations. Rating: 3.

Possible E.xplanations. Almost all of those dark days during which both the sun and stars are blotted out can be explained in lerms of: (1) forest fires; (2) volcanic eruptions; (3) dust stórms; and (4) intense storms, perhaps augmented by natural or artificial air pollutíon. \Vhen the stars appear during a dark day, one must search for extraterrestrial sources, such as cosmic material veiling the sun---------a very unlikely situalion.

Similar and Related Phenomena. Solar eclipses: dry fogs and dust fogs (GWD4); the white sky phenomenon (GWC1); earthquake fogs and darknesses (GQW5) the last in our catalog EarthquaKes, Tides----------

Examples of Dark Days and Other Obscurations

XI. 44 BC. Europe. The sun was palé for a whole year. (R12)

X2. 30. Mtddle East, Egypt. "The crucifician of Christ was signalised by phenomena in nature the most extraordinary and lerror-striking. The material creation seemed to have been moved into convulsive throes of synipathy with the last agonies of the Son of Gofl The sun refused to shme, and the earth robed herself in raourning. From the sixth hour there was darkness over all the land until the ninth---that is, from twelve r.'clock, our mid-da\, until three in the afternoon. /MI the región around Jerusalem was wrapped in a mysterious gloom. This darkness was not a natural event, and n was not a common eclipse of the sun, for ¡t was at the lime of the Passover, and that was set at full moon, when an eclipse is impossible. Besides a total eclipse can never last longer tban a quarter of an hour. It is reported that Díonysms in Egypt observed this portentous gloom, and exclaimed, 'Ei- ther the God of Nature is suffering, or the machine of the world is tumbling into ruin. mi9)

X3- 96. Ephesus, Greece. Disc of sun ob- scured so that Philostratue observed the corona. No eclipse that year. (R39)

X4. August 22, 358. Two hours of darkness followed by an earthquake. Probably in Europe (H12)

X5. 409. Europe. Stars visible during the day (R12)

X6. 536. Europe. Stnrs visible during the dey. (R13J This event is the famous 536-A.D. dry-fog/dust vell phenornenon. Detniis on Ibis near- global went nt GWD4-X7.

X7. 567. Europe. Stars visible during the day. <R12)
X8. 626. Europe. Stars seen durinp, the day. (R12)
X9. August 19, 733. Europe. Sun was dar- kened. (R12)
X10. 934. Europe. Sun lo6t its light. (R12) Xll.
September 29, 1091. Europe. The su» was darkened for three days. (R12)
Many meteors.
X12. February 12, 1106, Europe and Brazil. Sun darkened. Many meteors seen. (R12, R6) An extraterrestrial event?(\VRC)
X13. February 28, 1206. Europe. Sixhours of complete darkness. (R12)
X14. 1208. Brazil. Solar obscuration. (R8) X15.
1241. Europe. Stars seen during the day. (R12)
X16. April 23, 1547. Europe, Brazil. Sun the color of blood; many stars appeared during the daytime. (R7, R8, RIO, R12. R39) Once again a date coincidence on opposlte sides *oí* the Atlantic. Some sort of astronumical event may be in- ferred he re. i WR C)
X1T. 1706. Brazil. Obscuration of the sun. (R7, RS)
X18. 1574. Europe. The sun was darkened for 18 days. (1111)
X19. May 12, 1706. New Engiand. (R26)
X20. October 21, 1716. New Engiand. Ex- traordinary darkness at midday. (R15, R26)
X21. August 9, 1732, New Engiand. (1126)

X22. October 19, 1762. Detroit. Michigan. "A man in business seldom troubles himst-lf about news; yet the following is so uncommon, 1 cannot neglect acquainting you therewlth. Tuesday last, being the 19th instant, we had aJmost total darkness for most of the day. 1 got up at daybreak; about 10 minutes after 1 observed that it got no lighter than before; the same darkness continued until 9 o'clock, when it cleared up a little. We then, for the space of about a quarter ol an hour, saw the body oí the sun, which appeared as red as blood, and more than three times as large as usual. The air all this time, which was very dense, was of a dírty yellowish green color. 1 was obliged to light eandles to see to diñe, at 1 o'clock, notwithstanding the table was placed cióse by two large Windows. About 3 o'clock, the darkness became more horrible, which augmented until hall past three, when the wlnd breezed up from the S. W. and brought on some drops oí rain, or rather sulphur and dirt, for it appeared more llke the latter than the former, both in smeil and qualitv. 1 look out a leaf of clean paper and held it out to the rain, which rendered it black whenever the drops fell upon it; but when held near the fire, turned to a vellow color, and when burned, it fizzed on the paper iike wet powder. During this shower, the air was almost suífocating wlth a strong sulphur smeil; it cleared up a little after the rain. There were various conjec- tures about the cause of this natural incident. The Indians and unoducated among theFrench. said that the English, which had lately ar- rived from Niagra in the vessel, had brought the plague with them; others imagined it might have been orcasiuned by the burning of the woods. But 1 think it most probable, that it might have been occasioned by the eruptíon of some volcano, or subterraneous fire, wbereby the sulphurous matter xnay have been emitted In the air, and contained therein, until, meeting with some watery clouds, it has fallen down together witb the rain." (R26, R40)

X23. May 19, 1780. New Engiand. "This was the famous dark day of Friday, May 19, 1780, that extended over nearly all of New Engiand. One of the many eyewitness reporta still extant is a letter by Jeremy Bel- knap of Boston. He tells that the forenoon had been cloudy, and about 10 or 11 o'clock the clouds assumed a strange yellowish hue, which tinted all the landscape. An hourlater the light bogan to fail, and by 1 o'clock the darkness was so great that eandles were lighted and kept burning all afternoon. The atmosphere was not simply dark, said Dr. Belknap, but seeraed full of 'the smeil of a malt-house or a Cual-kiln. (R32) The pre- cipitation that fell was found to be thiek, dark, and sooty. (R35) Many other artícles mention this famous phenomenon. {R3, R14, R15, R26, R27)

X24 October 16, 1785. Quebec, Cañada. Several periods of intense darkness. Yel- lowish clouds carne from the northeast.
Black rain. Standing water found with a yellow substance floating on the surface, which was thought to be sulfur. (R2, R26) See GWF3 for "sulphur" falls.
X25. July 3, 1814. New Engiand and eastern Cañada. Darkness due to clouds carrying dust and wood ashes. (R2, R26) But see X26.
X26. 1814. Borneo. It was pitch black for 3 days due to volcanic dust from Tímboro Mountain 300 miles awaj. (R9) See X25.

X27. November 6-10, 1619. Eastern North America. "The darkness was so great (at Middlebury, ᵛermont), that a persoo- when

sitting by a window, could not see to read a book, ín small ty^pe, without serious inconveniente. Several of the students in the coliche studied the whole day by candle-light.
A number of the mechanics ln this viilage were unable to earry on their work without the assistance of lamps. The sky exhibited a palé yellow ish-white aspect, which, in some degree, resembled the evening twi- light a few moments before it disappears Indeed we had little else but twilight through íhe day; and such, too, as takes place when the sun is fíve or six degrees below thehori- zon. The culour of otijects was very remark- able. Every thíng I beheld wore a dull, smo- ky, melani'holv appearance. The paper, on which 1 was writing, had the same yellowish - white hue as the heavens. The íowlsshow- ed that peculiar restlessness that was re- marked in them durtng the total eclipse of the sun ln 1806. Some of them retí red to roost. The cocks crowed several hours in- cessantly, as they do at the dawning ofday." (RI) The phenomenon began on the 6th tn New* York State. On the 12th, residents of Georgia experíenced a smoky atmosphere that irritated the eyes. (RI, R13, R26)

X28. July 8, 1836. New England. (R2G)
X29, March 23, 1857. Europe. Glooni spread over the heavens, followed by 8 minutes of extreme darkness. (R5)
X30. May 20, 1857. Bagdad, Iraq. An ex- traordinary darkness. Much dust fell. (R4) Very likely a sandstorm. (WRC)
X31. April 11, 1860. Brazil. Several minutes of darkness, Venus visible. (R7, R8) R7 gives the date as April 16, but ít is evidently derived frorn R8, which has April 11.
X32. October 16, 1863. Cañada. (R26)
X33. September 15 through October 20, 1868. Western Oregon and Washington. (R26)
X34. September 6, 1881. New England. The Yellow Day. Clouds of smoke from forest fires in Michigan and Ontario made every- thing seem yellow. (R36)
X35. January 22, 1882. London. England. Not foggy but just like night at midday. **(R16)**
X36. April 26. 1884. Stonyhurst Observa- tory, England. Dense black clouds with yellowish tint. Black rain fell. !R17)

X37. Mareh 19, 1886. La Crosse, Wiscon- sin. "A most remarkable atmospheric phenomenon occurred here at 3 p. m. The day was light, though cloudy, when suddeniy darkne6S commenced settling down, and in five minutes it was as dark as midníght.

General consternation preval led; people on the streets rushed to and fro; teams dashed along, and women and cbildren ran intocel- lars; all business operations ceased untíl lights could he lighted. Not a breath ofair was stirring on the surface of the earth. The darkness lasted from eight to ten minutes, when ít passed off, seemingly from West to east, and brightness follow'ed. News from cities to the west say the same phenomenon was observed there is advance uf its appearance here, showing that the wave of darkness passed from west to east. Nothíng could be seen to indícate any air currents overhead. It seemed to be a wave of total darkness passing along without wind." (R18) Obviously, this was not the usual low- level concentration of smoke. (WRC)

X38. October 1886. Durkhamshire, England. (R20)
X39. November 19, 1887. Ohio River Val- ley . The Smoky Day. (R26)
X40. April 2, 1859. Áitken, Minnesota. Darkness accompanied bv dirty snuw. (R21)
X41. September 2, 1894. New England. (R26)
X42. July 1896. All of Siberia. immense arca covered with smoke for 11 days. No fires or volcanic sourc-es found. (R22)
X13. September 12, 1902. Western Washington. Everything was reddish, and one could not read outdoors. No forest fires found to explain phenomenon. (R23, R2C) X44. June 5, 1903. Saratoga, New York. (R26)
X45. April 15, 1904. Wimbleton, England. Like a tunnel of darkness, with light al either end. Lasted 10 minutes. (R24)
X46. December 2, 1904. Memphis. íenne- see. 15 minutes of darkness. (R26)
X47. June 30, 1908. Caterham Vallcy. England. Sudden onset of darkness that lasted 1/2 hour. (R25) Note that this dark day coincided with the famoue Tunguska Event or Siberian Meteor. |WRC)
X48. August 20-25, 1910. Northern United States from Idaho to St. Lawrence River. (R26)
X49. March 11, 1912. Sussex, England. lnky blaekness with blood rain. (R291 X50. February 28, 1923. New York, New York. So dark that all offices and vehicles had lights on. (R28)
X51. November 1924 or 1925. London, England. At 1145 it got darker and darker, by 1150 it was pitch black. bul at 1.159 the darkness disappeared ln a flash. (R37)

X52. September 18, 1938. Northwestern Siberia, between 7o and 90° east longitude and 65 tu 69° north Intitude. "The records that Yemiüanov has collected from docu- ments and eyewitnesses tell of a darkness Hke deep twillght, with a yellow cast to the sk>', lasting for severa] hours. This descripción recalls the New England 'dark dav' of May 19, 1780 which is known to havebeen the result of smoke from forest fires. How- ever the Siberian event cannot be so explain- ed, according to Y'emilianov. From a com- parison of the times of onset of the darken- ing at different places, he calcúlales that it was traveling east north east at approximate* ly 100 kilometers per hour. He believes it probable that the black cloud first appeared nearly simultaneously over an area about 300 kilometers in diarneter. He points out further that all but one of the eyewitnesses he interviewed did not mention any odor, such as vvood smoke occasion. Yemiüanov therefore concludes that the Siberian dark- ening was probably caused by a dense com- pact cloud of cosmic dust that entered the earth's atmosphere. " (R33, R34)

The above summary description of the "enigmatic Siberian darkness" was dls- tilled from two popular U.S. magazines. Much grentci detail is found in Yu.M. Emel'yanov's (The correct translation of his nnme) full report on the phenomenon. We have now translated this report from the original Russian. Of particular interest are Emel'yanov's personal cum- ments on the probable cause of the enigmatic darkness. This cause, if the correct one. make6 the phenomenon highly anomalous.

We quote two paragraphs from the translation of Emeryanov's concluaions.

"Thua, the only reasonnble origin of the black-cloud phenomenon appears to be extraterrestrial space. The black cloud probably originated from a suffi- iently dense condensation of cosmic dust fallíng during a short interval of time (no more than 1.0 to 1.5 hours) and staying suspended in the upper strata of the atmosphere.

"In regard to the transient nature of the fall of cosmic dust, it may be said that after the sudden appearance of the black cloud in the western part of the band of the 'ellipse', all further develop- ment of the phenomenon apparently con- sisted only in the diffusion of this cloud by atmospherin winds in en east-northeast direction with a speed of about 100 km/hr. There is no information at all about the descent at this time of additional cosmic dust in adjacent or more remete regions of the earlh."
(R42)

X53. January 16,, 1955. London, England. Abnormal smoke belt 11/2 miles wide caused 6-10 minutes of extreme dark- ness. (R30)

X54. December 1, 1961. London, England. (R31)

X55. April 30, 1971. Jacksonville, Florida. "An ominous overcast lowered uver down- town Jacksonville as tbe NWS issued a tornado warning In responso to a suspicious radar cell 48 km to the west. By 1030 EST, the sky turned nearly black. Lights and Street lamps carne on and birds circled to roost. An eerie eilence fell over the city. There was no thunder and no rain. " (R3u)
A typical darkness due to extreme weather conditions. (WRC)

X56. Circa 1800. Amsterdam, Holland. On a bright summer day, total darkness descended about noon. It was so dark that many lost their lives when they fell into canals. (R6)

X57. September 25, 1950. Ontario. "Inhabitsnts of Southern Ontario were startled on Sundav, September 25, 1950 at a brief glimpse of the sun as a palé, blui6h-mauve disc. At the same time the western sky became n dark, terrifying mass of cloud and haze, as though a gigantic storm were approaching, while to the north and east the sky teward the horizon was a clear steel-blue, The darkness was so marked at 3:30 in the after- noon that the writer observed a group of six wild ducks going to sleep quietly in the middle of a pond, with their hcads nodding or tucked under their wings.

"We learned on Sunday, even as the eerie darkness descended, that all this was attributable to smoke from heavy muskeg Fires in distnnt Alberta, two thousanri miles away. In subsequent days the smoke pall moved eastwnrd, causing similar phenomenn to be seen in eastern Cañada and the United States, and in the British Isles several days later." (R41)

The smoke cloud thus erossed most of North America and the Atlantic Ocean— a distance of perhaps 6,000 miles. Huw

could it retrdn its identity over such a great distance?

X58. November 6, 1961. Yugoslavia. "Beoause of a mysterious cloud, there was complete darkness at 13.30 h in the afternoon of November 6th , 1961, at Vukovar (Northern Yugoslavia).

"A dark-grey cloud of extraordinery shape eppenred above the village. The broadcast of the local radio-transmitter was interrupted and absolute darkness set in. which was accompanied by a half- minute long breakdown in the supply of electric power. Instruments showed that the atrooBphere was very strongly elee- ticRlly charged. A technician in the studio said that at this moment a series of fluorescent tubes started to give off light, although they were not connected to any power supply. After a short time the cloud was blown uway by the wind." (R43 citing Netherland's Einhovensch Dagblad, November 11, 1961) *

X59. August 6, 1981. Southern Engiand. On this date, the source of the excep- tional darkness experienced ís well known: violent thunderstorms. Neverthe- less, this darkness was so profound that it is worth recording here.

"The storms of 6 August 1981 were of rxceptional darkness and duration, which resuited in solar irradiance levels of less than the 1% percenlile 1?] and rainfall intensities with return period of over 100 years in many places in south eastern Engiand. From the evidence provided by the radiation valúes of twelve sites, there were two major storm systems: the lirsl arrived at Bracknell at about 0730 GMT, moved north and weakened over Bedfordshire and Cambridgeshire. The second system arrived at Bracknell at 0945 GMT and moved northeast producing lcwer valúes of global radiation than the first and heing associated with the speetacular thunderstorms and blackness of the sky widely reportetl in the Press. The storms lasted well into late afternoon and probably dissipated over the North Sea after sunset." (K46)

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GWD2 Pogonips and Other Ice Fogs

Descripüon. A winter fog occurring in high elevations characterized by Ihe rapid crystali- taiion of ice on animáis and objects. Inhalation of ice fog is reputed to cause death.

Background. Dangerous ice fogs are said to occur in many highly elevated areas, but the pogonip of Nevada is the only such fog treated in the literature examined sc> far.

Data Evaluation. The few reports found on ice fogs or pogonips have a sensational aspect ■ and cannot be taken too seriously. Ratina' 3.

Ano mal y Evaluation. The reputed dire biological effects of ice fogs. if true, have not been explained to the compiler's knowledge. Near-instant death upon inhaling fog would certainly tax medical theory. Rating: 2.

Possible Explanations. For the extreme biological effects reported, none.

Similar and Related Phenomena. Mists and epidemics (GWD3). where once again unusuai weather conditions are blamed for biological effects.

Exarnples of ice Fogs

XI. General observation. Nevada. "A curi- ous phenomenon is often witnessed in the mountainous dtstricts of Nevada. Mountain- eers cali it 'pogonip,' and describe it as be- ing a sort of frozen fog that appears some- tímes in winter, even on the clearest and brightest of days. In an instant the air is filled with floating needles of ice. To breath the pogonip is death to the lungs. When it comes, people rush to cover. The Indiana dread it as much as tbe whites. It appears to be caused by the sudden free- zlng in the air of the moisture which col- lects about the summits of the high peaks. " (Rl, R2) VV. J, Humphreys denies that the pogonip can cause death. (R3i

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GWD3 Mists and Epidemics

Description. The correlation of epidemics. particularly cholera outbreaks, with persistent mists or fogs.

Data Evaluation. The evidence linking mists to cholera epidemics is purely circumstantia! and unsupported by scientific observations. The tales about "blasting fogs" are extracted from popular histories and are also suspect. Rating. 3.

Anomalv Evaluation. Although swampy and poorly drained areas are often assoclated with malaria cholera, and other diseases, fogs and mists ID themselves should not be respon- sible for disease. H_ blue mists and blasting fogs, as described below, are truly involved ín epidemics, we have an important anomaly. Rating: 2.

Possible Explanation. The association of mists and cholera is probably just coincidental. It is possible that extreme coid and dampness (blasting fogs) eould weaken plants and en- courags rusts and otHor plíuit discases.

Similar and Related Phenomena. The tbeorized influx of virases and bacteria from outer space vía cosmic dust.

GWD3 MISTS AND EPIDEMICS

Examples of Fogs or Mists Correlated with Disease

XI. 1832. England. Correlation of a blue mist and cholera. (RI)

X2. 1848-1849. England. Correlation of a blue mist and cholera. (RI)

X3. 1854. England. Correlation of a blue mist and cholera. (RI)

X4. 1866. Greenwich, England. "According to Mr. Glaisher, there was a particular State of the atmosphere during the three epidemics of cholera in 1832, 1848-1849, and 1854, characterised by a prevalent mist, thin in high places, dense in low. On the 30th ult. this gentleman, while íooking from the grounds *oí* the Roy al Observatory. Greenwich, under the trees towards the boundary walls of the park, saw a dense blue mist (similar to what he had observed in 1854), which continued without intermis- sion to the 6th inst. Ordinary mists pass away with the wind blowing at a pressure oí half a pound to the square foot; but this mist was immovable before a wind blowing at a pressure of nine pounds on the same arc3. Jt was apparent on all sides, and extended fully to the tops of the trees, tbough not there so easy to distinguish. It was most easlly discernible through as much atmosphere as possible, viewed from under a tree and looking under other trees. Tbus seen, the boundary walls of Greenwich park and all objeets near them were coloured blue. When looked at through gaps in tr»-cs, if there were others at a sufficient distance to form a background, it resembled thin smoke from a wood fire. The intensity of the blue was increased when viewed through a tele- scope with a low power. The only other mist which Mr. Glaisher knows connected with the prevalence of an epidennc is a yellow mist perceptible when scarlatina is prevalent." (RI) Blue mist seen on the Isle <>f Wight during the cholera epidemic. (R2)

X5. Early December 1930. Belgium. A dense fog was followed by 40 human and rnany animal deaths. Mud rains in parts of Europe. The deaths, however, were probably due to a higb eoncentration of industrial pollutants under a temperature inversión. (R3, R4) Much was made of this incident at the time, but it scems identical to modern smug deaths,

X6. August 1694. Scotland. During the night, a raw east wind from the North Sea blew over the county oí t romarly , to the north of Loch Ness, and was accumpanied bv a dense sulphur-smelling fog. The superstitious peasants opined that it was coming straight from the mouth of Hell. As dawm broke, this strange fog was already lifting in spots, but in many places it w as heaped up ín what was said to be like 'mountains of vapor', towering over valleys and dales. Soon, however, these too dissipated under
the sun's rays-----but a ghastly prospect w'as presented to the eve in the oatfíelds where the grain had been ripening with every indication of an early and bounteous harvest.
A sort of mildew' lay sprlnkled on both blade and ear; as the sun shone on it, this mildew whitened and took on the appearance of flour, while the affected parts of the plants shrank and shriveled. In a few hours it was apparent that almost the entire crop had been destroyed—the worst devastation beíng In those flelds over which the poísonous fog had lain the longest. " (R5) There is some similarity between these "blasting fogs" and salí storms. See GWF4-X2.

X7. August 1720. Scotland. A "blasting fog" similar to that in X6. (R5)

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R4. "Noxlous Fog in the Meuse Valley, " Geographical Journal, 81:378, 1933. (X5) R5. Rothovíus, Andrew E.; "The 'Blasting Fogs' of Scotland, " lisFO Journal, 1:2, Spring ly69. (X6, X7)

GWD4 Dry Fogs and Dust Fogs

Description. Widespread hues consisting oí very fine, dry partióles, usually dust, suspended in the aír. Visibility in dusl fogs ls frequently severely limited, and the sun and moon are highly colored. Breathing may be impaired, and some experienee a general maiaise. Dust fogs may cover continent-sized areas and cuntribute to colored precipita- tior hundreds oí miles from the dust's origin. Some dust fogs have seemed to be self-lumi- nous at night.

Backgrouttd. The Cape Verde dust fogs .,«r red fogs have been recorded for cenluries, not only far out into the Atlantic but far into Europe.

Data Evaluatiun. The true dust fogs have been deseribed frequently. The mure emgmatic dry fogs of 1TS3 and 1831» which afflieted much of the globe, are citen mentioned in theolder literature, but no scientific studies have yet been uncovered. Rating: 1.

Anomaly Evaluation. The frequent dust fogs radiating out from North Africa and the Easl Indies are included in this CataJog beeause, even though they are well-known and basically understood, they are remarkable in their geographical extent and meteorulogical effects.
The following rating applies only to the great luminous dry fogs (as exempljfied bv the 1783 episode), which present serious problems in explanation. Rating- 2.

Possible Explanatiops. It is difficult tu come to grips with the global dry fogs. One scien- tist proposed that the earth passed through a comet's tail in 17b3. The luminosity of these dry fogs at night makes thern resemble low-level auroras, which may mean they have an electrical origin.

Similar and Reiated Phenomena, The white sky phenomenon (GWC1); dark davs and obscurations (GWD1). Low-level auroras (GLA4). aurora! fogs and mists (GLA21). both in our cat&iog Remarkable Luminous Phenomena.

Examples of Dry Fogs

XI. Summer 1783. Much of the earth. A peculiar fog. ". . . it began on the 18th of June and at places very remóte from each other. It extended from Africa to Sweden. and throughout North and South America.
This Fog continued more than a rnonth. It did not appear to be carried to different places by the atmospbere; beeause in some places it carne on with a north wind and at others with a South or east wind, it pre- vailed in the highest summits of the Alps as w-ell as in the lowest \alieys. The rains which were very abundant in June and July díd not appear to disperse it in the least. (n Languedoc ¡ts density was so great that the Sun did not become visible in the morning till it was twelve degrees above the horizon; it appeared very red during the rest oí the day and might be looked at with the naked eyo. This Fo^or Smoke hari a diagreeable smell and was entirely destitute oí any mois- íure, whereas most togs are moist; besides all tlus there was oue remarkable quality in the Fog or Smoke of 1783, it appeared to possess a ph&sphonc property, or **a** light $_{0}$f ,!«. own. We find by the accounts ofsome observers, that it 'ifforded even at rmd- night a light equal to that of the full moon, and which was sufficient to enable a person to see objeets distinctly at a distancc oilwo hundrtd yards, and to remove all duubtsas to the source of this light, it is recorded that at the time there was a New Moon."
(R2) Also seen in Asia. Blamed on an erup- tion of Mounl Hecla. »RD First scen in Scandanavia un May 23, 1783. (Rll) Also mentioned in many other articles. (R4, R12- R13 J

G. White, author of the elassie Natural History of Selbourne. mentioned other curious featuree of the remarkable summer of 1783. W.H Larrabee quoted White in his summary p»p^{o}r >*n tío 1783 phenomenon in an 18P4 number "f Popular Science Monthly (the forerunner of today’s Popular Science-^-but more tech- nical).

"The summer of the year 1783 was an amazing and pretentious one, and full of horrible phenomeim; for besides the alarmirig m^teors and tremendous thunder- storms that affrighted and distressed the different counties of this kingdom. the peculiar haze, or smoky log Dial prevaíled for many weeks in this tsland,

and in every part of Europe, and even beyond the limits, was e most extra- ordinary appearance, unlike anythíng known within the memory of man. By my journal I find that I had notíced this occurrence from June 23d to July 20th, inclusive, during which period the wind varied to every quarter, without making any alteration in the air. The sun, at noon, looked as black as a clouded moon, and shed a rust-co]ored ferruginous light on the ground and floors of rooms, but was particularly lurid and biood- colored at rising and setting.. .The country people began to look with a suspieious awe at the red, lowering nspect of the sun, and indeed, there was reason for the most enlightened person to be apprehensive, for all the while Calabria, and part of the Isle of Sicily, were torn and convulsed with earthquake; and, about that juncture. p. volcnno sprang out of the sen on the coast of Norway." (R15)

X2. August 1821. Western Europe. This dry fog was similar to that of 1783 and lasted 12 days. (R4)

X3. May 1822. Europe. Another dry fog appeared suddenly. (R4)

X4. 1831. Almost worldwide. One could look directly at the sun. Nights were so bright that the smallest print could be read at midnight. (R4, R13, R14)

X5. Frequent occurrence. From Cape Verde hundreds of miles out into the Atlantic plus mueh of western Europe. The fol- owing account is from Teneriffe, ín the Canary Islands. "From the fírst hours of the evening of February 15 (1898), there was observed a sensible but light fog; nei- ther the strength of the wind (E. gentle breeze) ñor any other phenomenon indicated that the supposed condensed vapours could be African dust transported by air. As the night advanced, the forcé of the wind in- creased, until it reached the valué of a modérate gale. At about 5 a. m. on the IGth, some laxge drops of rain fell, but were inapprecíable in the rain gauge. For a ver* short time the wind subsided, by and by again becoming a gentle breeze dur-ing the day and blowing due E. The fog be-came more dense, rausing depresstonand a disagreeable feeling produced by itsdry- ness. The sun, on account of iís lightbelng palé íuid feeble without the usual rays, was eonfounded with the moon; and ít reminded one of the light of a voltaic are seen through a frosted glass. The flame of a match ap peared with a very marked vlolet hue. The drínking waters became salty and coloured as by oxide of iron. The dust was grey and extremely fine, and deposited itselí on every object. " (R6) (R3, R5, R7, RIO)

XG. Frequent occurrence. EastIndían Archipelago. The dry fog of 1914. "The fog had a grey colour, and was most intense in the month of September, and especially in October, and disappeared when the rains fell. In íts most typícal form it appeared in Sumatra, in the neighborhood of Ambón and the islands to the southeast... .In the xnorning the sun was not visible before eight o'clock, when it appeared as a ditn red diec. Objects in general were barely visible at 500 metres' distance, and on the thickest days invisible within halfthis distance; the mountains had disappeared entirely from view." (R9) Another major recurrence in October 1902. (R8)

X7. 53G A.D. and 537 A.D.. Mucb of Europe and the Middle East. We introduce this catastrophíc event of ancient times with an overview by R.B. Stothers fron the January 26, 1984 number of Nature.

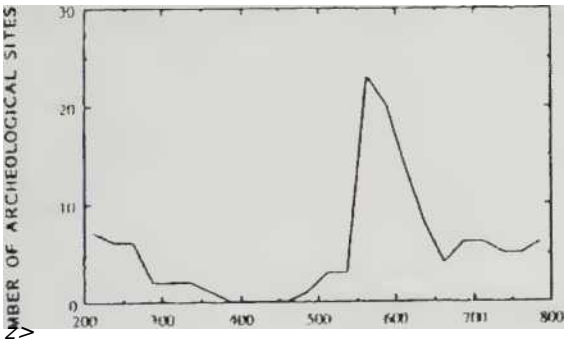
"Dry fogs appenr In the atmosphere when large voleante eruptions inject massive quantities of fine silicate ash and aerosol-forming sulphur gases into the troposphere and stratosphere. Al- though the ash gravitationally settles out within weeks, the aerosols spread around the globe and can remain suspended in the stratosphere for years. Because solar radiation is easily absorbed and backscBltered by the volcanic partióles, a haziness in the sky and a dimming of the Sun and Moon are pro-duced. Very dense and widespread dry fogs oecur, on the averege, once every few centuries. The sizes and intensities of some of the largest of them before the niodern scientific era have been estimated by Beveral indirect methods. The densest and most persistent dry fog on record was observed in Europe and the Middle East during AD 536 and 537. Despite the earliness of the date, there is sufficient detailed information to estímate the optical depth and mass of this remarkable stratospheric dust cloud.

The importance of this cloud resides in the faet that its mass and lts cliroatic consequences appear to exceed those of any other volcanic clouds observed during the past three millennia. Although the volcano responsible remains a mys-

tery, a tropical location (perhaps the volcano Rebaul on the island of New Britain, Papua, New Guinea) can be tentatively ínferred."

As seen in the quote from Stothers' paper above, volcanism has long been considerad tlie primary cause of the 536-A.D. "dry fog" or "dust-veil event." M.G.L Baillie challenged this consensos explanation in 1994. The London Times expended on Baillie's contrary extra-terrestrial thesis:

"Now tree-ring data, published by Professor Mike Baillie of Queens Univer- sity of Belfast, has brought catastrophes almost intn modern times. The tree rings
show that in the mid 530s----------just about the time civilisation on Earth suffered a sharp setback—there was a sudden decline in the rate of tree growth which lasted about 15 years. Clearly, some- thing dramatie had happened.



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OATES IA.D.J

Following the dry fog of 536 A . D . there was ***o*** *suddtn, difficult-to-explain increase in the* ***n****umber of European arche- ologicai sites. The imphcation* ***is ffiat*** *the calastrophe somehow* ***reverted the dou nward*** *trend of European civilization existing prior to the* ***5****36 event (noted in R20) . Interestingly, rebounds* ***<n*** *biológica} diversity ore o fíen seen* ***in*** *the fossíl record after majar catastrophic events! (FU 9)*

"There are two possibilities: a huge voleanic eruption or n collision between the Earth and a solid objeet: an asteroid or comet. Ice-cores drilled from Grcen- land show no evidence of large-scale volcante activity st that time, so Pro fessor Baillie ond others now believe a cosmic impact is more likely. The result woulri have been to throw up a huge veil of dust and debris, rooling the Earth and produeing widespread crop failures."

Iri the scientific literature (R19), Baillie has elaborated on the cosmic- projeetile theme, adding also that the dust veil could also have been created when the solar system passed through a cloud of cosmic dust.

The scientific literature hints at dust-veil events in more recent times:

(1) the white-sky phenomenon of 1912;

(2) the "dry fog" of 1783.

See details in GWC1 and GWD4-X1.

X8. General observations. The extrn- terrestrial explanation for the 536-A.D. dry fog advenced by Baillie in X7 has been contradicted by an historieal survey by R.B. Stothers. He surveyed the historieal data and shows that episodes of terrestrial volcanism correlated well with the ma}or dry fogs, including that of 536 A.D. (R17)

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GWF FALLS

Key to Phenomena

GWFO Introduction
GWF1 lee Falls or Hydrometeors
GWF2 Stone Falls
GWF3 Sulphur/Pollen Falls
GWF4 Falls of Miscellaneous Inorganlc Substances
GWF5 The Fall of Marina
GWF6 Unusua! Falls of Hay and Leaves
GWF7 Gelatinous Meteors or Pwdre Ser
GWF8 Prodigious Falls of Web-like Material
GWF9 Falls of Miscellaneous Organic Substances
GWF10 Fish Falls
GWF11 Falls of Frogs and Toads
GWF12 Insect Falls
GWF13 Bird Falls
GWF14 Falls of MiscellaneousLiving Animáis
GWF 15 Fall of Giant Dust Particles from Distant Sources

GWFO Introduction

Anomalous rain, snow, and hail are treated in the next cbapter. Beyond these "nearly normal" forms of precipitation are those falling materials that do not belong aloft at all: large chunks of ice, living animáis, non-meteoric stones, and many other nominallv terrestrial materials. Charles Fort made much of falling materials, even though most of them can be explained rationally by appealing to recognized meteorological mechanisms; i.e. . whírl- winds, waterspouts, tornados, etc. Fort did have a point, however, any small minority of falling material not succumbing to conventional explanations would require truly revolution- ary explanations. Such is the claim of residual anomalies in all areas of Science and this claim is perfectly valid in this chapter.

The overwhelming majority of falls consist of terrestrially derived material and earth-dwel- ling animáis. So-called sulphur falls almost invariably turn out to be wind-blown pollen.

The sensationalized falls of fish and frogs, which are well-verified in the literature, are easily explained in terms of whirlwinds, waterspouts, and tornados. Immense falls of hay, leaves, and inseets, though startling, are scarcely anomalous. Nature provides ready sources of such material as well as natural vacuum cleaners to snaleh up light-weight ob- jeets and deposit them somewhere else. Even so, these types of falls present some enig- matic aspeets: (1) The descent of some species of anímals is so overwhelming in quantity that scientists are hard-pressed to explain where they could have all been eollected; (2) The "purity" of the falls; that is, the abseDce of coexísting species and debris from the falling animáis* habitat.

Falls of cobwebs and the so-called gelatinous meteors (or "pwdre ser") introduce a more

unsettling factor. While admítting the reality of ballooning spiders. it eeeras tbat some of the great web falis involve a substance tbat may not be insect-produced it is too strong and quickly evaporates away. It also falls Ln strands hundreds, even thousands of feet long. Some gelatinous meteors, too, seem to evapórate away strangely. If these properties can be verifted, we have something more anomalous than a simple fish faíl.
Another pair of pbenomena with related characteristics will conclude this introduction: tbe large hydrometeors and the mueh-maligned thunderstone. Both phenomena typically occur during thunderstorms. A peal of thunder rings out and something strikes tbe ground nearby- If one finds a large chunk of ice, a paesing plañe can always be blamed; bul if one finds a stone or even a meteor emotíonal disbelief takes eharge. Yet, no physical reason bars the faJ 1 of meteorites during thunderstorms, ñor can one deny the possibility of a strong whirl- wind picking up a stone of severa! pounds weight and releasing it during a thunderstorm. After all some large hailstones reach several pounds, too. The polnt here is that the possibility of stonefaUs should not be dismissed out-of-hand because of any innate distrust of legends carried over from ancient times. The data presented below show rather conclusively tbat odd things do fall from the sky on occasion. Regardless of the sensationalism usually attached to these falls, most of them are not really very anomalous. A rain of frogs may be rare and certainly Portean, but meteorologv is well-equipped to deal with most aspects of this phenomenon.

GWF1 Ice Falls or Hydrometeors

Descríption. Chunks of ice that are substantially larger than the largest recognized hailstones; that is, more than 5 inches across and weighing more than 2 pounds. These ice masses often fall from a olear sky (sometimes with a whisUing sound), or they may descend after a powerful boit of lightning. The ice chunks may be crystal clear or layered or aggregations of smail hailstones. Large blue- colored ice chunks are eliminated from consideraron as having likely originated in leaky aircraft lavatories.

The diversity of fallen ice structures and the different meteorological condítions associated with them suggests that they may have several different origms.

Background. Today, the fall of large ice chunks is customarily blamed upon aircraft passing overhead. Blueish-ice "bombs" from leaky lavatories doubtless falls, off aircraft on rare occasions, but there are many pre-Wright examples of ice falls a.k.a. "hydrometeors". Nevertheless, most scientísts discount these early reports and are satisfied with the aircraft explanation. The general publie is, too. Other origins. especially extraterrestrial sources; that is, true ice meteors; are routinely rejected by meteorologists, who doubt their survival in the heat of atmospheric reentry.

Data Evaluation. Some of the pre-1900 ice falls recorded below may be apocryphal, but there is no denying the many modern reports of ice falls. Unfortunately, these data are mainly anécdota!. Yet, their sheer number and the quick pre- servation of some of the íce masses for analysis, make it hard to deny that large
ice masses do indeed sometimes fall from the sky----------even from clear skies with no aircraft detectable by eye or radar in the affected areas. Rating 1.

Anomaly Evaluation. Many of the fallen ice masses under discussion are so large that the theory of hail formation is inadequate. By OUT definition, aircraft blue ice "bombs" are also eliminated. Indeed, some íce falls are so large thut aircraft performance would be compromised. Conventional explanatíons, therefore, do not suffice here. Rating: 2.

Possible Explanations. (1) Vertical winds ín storm cells may be mueh stronger than currently recognized----------strong enough to suppcrt very large hailstones. (2) Some unnppreciated storm raechanism may cause the aggregation of many small hailstones. (3) Despite scientific doubts, some hydrometeors may be the remains of reentering ^xtraterrestrial ice masses; that is, true ice meteors. Modern close-up observations of comets and even some asteroids reveal thai pieces of ice do exist in outer space in a wide range of sízes.

Similar and Related Phenomena. The fall of mt-ieor-like objects during thunder- Ftorms (GWF2); giant snowflakes (GWP2); giant hailstones (GWP5); iev miniconets (GWC20) .

Examples of lee Falls

XI. Late 1700s. Seringapatam, India. A block of ice as big as an elephant fell during the reign of Tippoo Sahib. It took three days to melt. (R1-R3) This purported event has always been a sub- ject of derisíon. (WRC)

X2. May 8, 1802. Hungary Mass of ice 3 feet long, 3 feet wide, and more than 2 feet thick fell during a storm. (R4, R5) X3. May 12, 1811. Derbyshire, England. Lunips of ice a foot in circumference. (R4)

X4. July 24, 3 818. Orkney Islands, Scot- land. Jagged pieces of ice, some a foot long. When melted they emitted a sul- phurous odor. (R4)

X5. 1826. Khandeish, India. A block of ice with a volume of a cubic yard. (R2, R4) The date is sonietímes given as 1828.

X6. June 15, 1829. Cazo ría, Spain. A block weighíng 2 kilogratns. (R5)

X7. April 1838. Dharwar, India. A mass of hailstones measuring 20 feet in its lar- gest dimensión. (R3, R2)

X8. May 22, 1838. Near Bangalore, India. Immense mass ol hailstones cemented together found in a well. (R2, R3)

X9. October 1841. Cette, France. A block of ice weighíng 5 kilograms fell. (R4, R5)

X10. August 1849. Scotland. "A curíous phenomenon occurred at the farm of Balvuí- lich, on the estáte of Ord, occupied by Mr Moffat, on the evening of Monday last. Im- mediately after one of the loudest peáis of thunder heard there, a large and irregular- shaped mass of ice, reckoned to be nearly 20 feet in circumference, and of a propor- tionate thirkness, fell near the farmhouse.

It. had a beautiful crystalline appearance. being nearly all quite íransparent, if we ex- eept a small [lortíon of it which conslsted of hailstones of uncommon size, tixed together. It was principally composed of small squares, diamond-shaped, of frorn 1 to 3 inches in size, all firmly congealed together. The weight of this large piect of ice eould notbe ascertained; but it is a most fortúnate cir- cumstance, that it did not fal) on Mr Moffat's house, or it would h3ve erushed it, and un- doubtedly have caused the death of some of the inmates. No appearance whatever of either hail or snow was discernible in the surrounding district. " (R4-R8)

XIl. May 22, 1851. Bangalore, India. Ice niasses as large at pumpkins. (R4)

X12. August 1857 Cricklewood, England. 25-pound mass of ice found on ground. Assumed to have falli-n there. (R4)

X13. March 16, 1860. Upper Wasdale, England. Blocks of ice fell in a snowstorm. Looked like a flock of sheep on the ground. (R4)

X14. June 1881. Iowa- Mass of ice 21 inches ín circumference falls with hail. (R4)

X15. August 1882. Salina, Kansas. An 80- pound hailstone. (R4, R9)

X1C. December 6, 1893. Texas. A 4-pound lump of ice fell. (R4)

X17. August 1897. Scotland. .. a thunder- storm accompanied by heavy hail, although the hailstones were generally noted to be no larger than usual. However, shortly after the storm had passed away. at about 5 p. in., a shepherd saw wbat appeared to be a sheep lying prostrate on the ground. On closer inspection he found it to be a block of ice which he estimated to weigh about 50 kg. By the next morning this hadn't melted away but had broken up into smaller pieces. "(RIO)

X18. September 11, 1949. Stepbens County, Texas. A 40-pound chunk of ice lands 15 feet from a Dr. Robert Botts, (R4)

X19. November 10, 1950. Bristol Channcl, England. A chunk of ice weighíng 14 pounds kills a sheep, Other large chunks found on ground. (R 1)

X20. November 24, 1950, London, England. A piece of ice aboji *n* cubic foot in si/e

smashes through a garage roof. (R4)

X21. Noveruber 30, 1950. Hampstead Norria, England. Ah ice block, 15 inehes long, 7 inches wide, 4 inches thick, falls ínto a garden. (R4)

X22. December 26, 1950. Dunbarton, Scot- land. Man sees a mass oí ice fal! on road and sroash tu pieces. 112 pounds of ice collected. (R4)

X23. 1951. Kempten, Germany. A carpen- ter working on a roof was killed by a piece of falling ice fe feet long and 6 inches round. (R4)

X24. June 4, 1953. Long Beach, California. Fifty ice lumps, some weighing 75 kilo- grams each, fell. Total weight about 1 ton, (R5)

X25. January 1955. Los Angeles, California. Largo chunks of ice fall, weighing be- tween b and 26 pounds. (R4)

X26. July 30, 1957. Reading, Pennsylvania. Man and wife see a piece of ice 2 feet in diameter fall near them. (R4)

X27. January 26, 1953. San Rafael, California. Slab of ice. 2 feet square and several inches thick fell through the roof of a house. (R4)

X28. September b, 1958. Chester, Pennsyl- vania. Largo ice chunk crashes through the roof ol a warehouse. (R4)

X29. 1959. Toccoa, Georgia. 30-pound ice chunk falls. (R4)

X30. September 11, 1959. Buffalo, New York. Ice chunk 1 foot long narrowly misses a child. <R4)

X31. December 1959. London, England. Basket- ball-sized ice mass damages a house. (R4)

X32. Oetober 16, 1960. Melbourne, Australia. Two ice lumps the size of footballs just miss two golfers. (R4)

X33. February 1965. Woods Cross, l'tah. 50- pound íce mass fell through the roof of the Phillips Petroleum Plant. (R4)

X34. February 1965. Aptos, California. A foot- long ice chunk falls on a house. (R4) X35.

February 5, 1963. Washington, D C. A piece of íce 7-8 inches in diameter fell through an awning. (R4)

X36. February 22 or 23, 1969. Bracknell, England. Large ice mass crashes through the roof of a parked van. (R5)

X3". August 16. 1970. London, England. Large ice inass crashes through the rool of a house. \R5, Rt>)

X3S. August 19, 1971. Bríve, France. A hailstone the size of a grapefruit injures a girl. üther hailstones weighing up to 3 pounds crashed through the roofs of nouses. ÍR5)

X39, January 23, 1972. Sur rey, England A 4-foot, square block of ice fell. (R5)

X40. May 24, 1972, Riverstde, California. "Building damaged by ice 'bomb': A chunk of ice weighing between 30 and 50 pounds fell from the sky and ripped through the roof of a downtowm Riverside law office building and landed on a third floor haliway. No one was injured but damage to the building was estímated at several hundred dol- lars. Observing the evidence before it mel- ted, authoritíes theorized il might have fallen from a passing plañe, but a spokesman for the Federal Aviaüon Arlministration said heknewof no aircraft in the areaat the time. " (R121 Attributed to the Los Angeles Times,

X41. January 9, 1973. West Wickham, England. 10-pound block of ice shatters a front porch. (R5)

X42. April 2, 1973. Manchester, England. "A fragment of a very large hydrometeor was analysed in the laboratory where standard tbin- section techniques were used to reveal its structure. The ice fell at the time of a severe lightning stroke which occurred in Manchester on 2 April 1973, a day when heavy rainfall was recordad in the area. In- quiries have revealed the pattern of nearby

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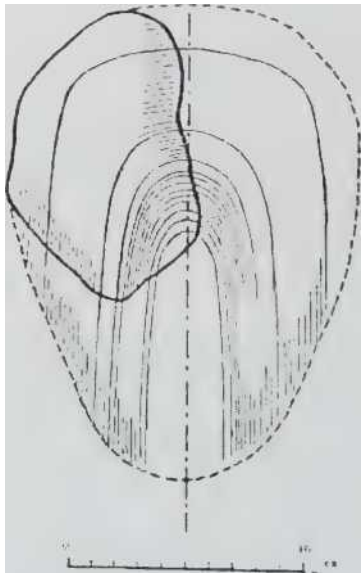


Layered structure of a large hydrometeor (X42)

aircraft movements at the time, and it ls suggested that the lightning was triggered off by an aeroplane whicb flew into the storm. No definite conclusión as to the origin of the sample has been arrived at, except that u was eomposed of cloud water. " The ice chunk fel! 3 meters from the observer and scattered pieces around. Weight estímate of the composite mass was about 1-2 kilo- grams. (R5, RS, R13) One theory proposed that such large hydrometeors may form in the lightning discharge channels with the help of the electrostatic acceleration of mat- ter. (R14-R17)

X43. Septembcr 22, 1973. Wombwell, Eng- land. A ball oí ice crashes through a house roof. A fragment weighed 6 pounds. (R5, R8)

X44. December 13, 1973. Fort Pierce, Florida. An ice chimk roughly 10 inches in diameter fell through the roof of a house almost simultaneous with the launch of a Titán 3-C rocket from Cape Cañaveral. Chemical analysis showed an unusual eon- centration of heavy metáis. Sinee the rocket trajectory was out over the Atlantic rather than Fort Pierce, it was suggested that the chunk carne from an air- plane passing overhead. (R15)

X45. March 25, 1974. Pinner, England. A cuboídal mass of ice about 18 inches in diameter erashed into a car. A bucket of yellowish-brown ice was collected.
May have fallen from an aircraft. (R5)

X46. January 24, 1975. London, Englantl. A block of ice weighing about 50 pounds feli on an apartment roof. (R5, R19)

X47. March 7, 197G. Timberville, Virginia. Two blocks of ice fall. One was about the size of a basketball. It smashed through a tin roof. Chemical tests showed the pieces to be similar to local tapwater. (R20)

X48. January 2. 1977. Middlesex, England. A large ice chunk crashes through a bed- room ceilrng. Size estímate: 3 feet long, 12-15 inches wide, 6-8 inches thick, weight more than 100 pounds. ÍR5, R21)

X49. May 1979. Forked River, New Jersey. "Robert Cloupe and his son Robbie wereout in their garden in Forked River, Ocean County, New Jersey plantíng some vegetables on an overcast Memorial Day, 1979, when they were startled by a whistling sound in the sky. The s_c,und. 'like a firecracker makes before it explddes,' Mr. Cloupe said, occurrcd around 2:45 p. m. Robbie told his father to look above them and together they observed 'something' falling several hundred feet to land in a field next to their nelghbor*s house a short dístance away.... The object, they discovered, was apparently an ice bal!. Having left a six-inch deep depression inthe ground where it landed, the mam mass had then broken up into 'grapefrult-sized chunks[1] sb. to eight inches in diameter which were spread over an arca some 25 feet across. " The object consisted of semihard ice and compacted snow. (R22)

X50. March 1982. Tecumseh, Oklahoma. An ice mass estímated at 30 pounds fell on the land of A. C. Hinson. Investiga- ting meteorologista said that it was not a hailstone but niigbt have fallen from an airplane or even come from outer space. (R23)

X51. September 1964. Transvaal, South Africa. "A large iump of ice fell from acloud- less sky one morning in September 1964 and landed only ten yards from a farmer in the Brits district of the Transvaal, South Africa. A whlrring sound shortly before the impact alerted the farmer so that he saw the ice as it struck the ground. The lump was ílattish- shaped and irregular, estímated at 11 x 9 x 6 inches, and gave off a peculiar odor, The farmer also observed that the ice was coni- posed of numerous layers and that parts of its interior were brownisb-coloured. He did not recall noticing aircraft in thevicinity' at the time ol the incident." This ice fall was later correlated with the passage overhead of an aircraft descending for landing. (Rll)

X52. October 30, 1959. Beechwood, Missouri. Two basketbail-size chunks of ice fell in this lócale. One smashed through the roof of a house; the other on a fairway about 100 yards from twu golfers. The Weather Bureau stated that conditions that day were not cunducive to íce forming on aircraft. (R24)

X53. April 11, 1983. Wuxi, China. "Around midday (1250), on 11 April 1983, Sheep's Skin Lañe, the east China city of Wuxi, was bustling with passers- by. Suddenly, a block of ice hurtled from the sky and splintered on the pave- ment in front of them. The block was 50-60 eentimeters in diameter and 50 kilogrammes in weight." Chínese eclen- tists presumed that the ice block carne from outer space and estirnated that before the heat of atmosphí ríe reentry, the ice mass probably weighed about a ton. (P.25. R26)

GWF1 ICE FALLS

X54- June 824 A.D., Autun, France.
The following quotation comes froni a very oíd record of major European events, "A few days before the summer equinox, an enormous chunk of ice is said to have fallen with the hail ir» the country around Autun. It is said to have been 15 feet long, 7 feet wide, and 2 feet thick." (R27)

A fabulous and marvelous account, and perhaps apocryph&l.

X55. August 1984. Kazan, U.S.S.R. "A Russian vacetion camp supervisor was narrowly missed being struck by a block of ice falling from a cloudless sky has provided Soviet scientists with their first sample of an "ice meteorite," a Soviet report said yesterday.

"Anatoly Kozhukhov heard a whistling noise and jumped out of the way as the chunk of íce thudded into the sand two paces away from him at a carnp near Kazan on the Volgtt River, the news agency Tass reported." (R28)

X56. June 26, 1985. Hartford, Conneeti- eut. "Scientists yesterday tried to determine the origin of a 1,500-pound mass of ice that inysteriously dropped from the sky and smashed into a backyard fence.

"David 11. Menke, director of the Copernican Observatory, said the ice was probably 6 feet long, 8 inches thick and moved at about 2ü0 mph.

"’It's unusual in the fact that it fell from the sky,' said Craig Robínson, eurator of the planetarium. 'That does not happen often.'

"A 13-year-old boy was in bis yard Monday with a friend when the ice carne ’whirring’ from the sky and smashed into the fence about 10 feet away from them."

Robinson doubted that such a large mass of ice could have come from an airplane. (R29)

X57. June 1990. Jerrys Run, West Vig- ginia. "Heisel and Alice Amos, and their grandson, Aaron Hupp, had just turned on a movie on televisión when the house was jarred with what Mrs. Amos thought was an explosión.

"Looking out the íront door, they saw their son, Donald, 43, looking in the direction of their televisión satel- lite dish some 30 yarda away where something had hit the ground with a terrific iropact.

"Inspecting that area, they found a hole some 2 4 inches long and 18 inches wide, and about four to síx inches deep fillod with large chunks of broken íce. Amos said pieces of baseball- and marble- size ice were scattered in a 30-foot radius around the hole."

Further facts from this newspaper account :

1. Severa! other chur.ks of ice were found in an areu about 1 mile lorig;
2. Some chunks made whistling sounds as they fell;
3. The larger chunks were complete- ly transparent except for a yellowish- brown streak;
4. Man y of the chunks hed sand in them;
5. Some contained holes;
6. The weather was olear;
7. The Federal Aviation Administra- tion stated that if the ice originated in aircraft toilcts it would have been blue due to the Chemicals used. (R30)

X56. June 15, 1993. New Monterey, California. A report from b local paper: "On June 15, 1993, two large, basketball- sized chunks of ice fell from the sky and carne down in two sepárate locatíons in New Monterey, California. The two incidente occurred at 12:30 p.m., two blocks apart. BRttalion Chief Mike Cooley of the Monterey Fire Department said two men working on a nearby roof told fire- fighters they heard a whistling sound and then saw something smash through the roof of an apurtment house at 803 Hawthorne Avenue. It maae a bowling- ball-size hole in the building's loof and ceiling and landed on a bed in an apart- ment below, where it shattered.

"The second ieeball landed with 'a big whomp'and splattered on the side- walk in front of the Knapp Mili and Cabinet Company, located at 775 Foam Street." (R31)

The FAA stated that no aircraft were in the vicinity of Monterey at 12:30 P.M.

X59, March 23, 1995. Yaodou Village, Zhejieng Province. China. On April 3,
1995, The Reuter news agencv provided some interesting details on thís ice fall.

"Chínese experts have recovered what they believp to be chunks of a meteoric ice that fell to Earth in Zhejiang Province, Xinhua news agency said.

"Amateur geologlst Zhong Gongpei was nearby. Ion} March 23, when farmers saw three large chunks of ice crash

with a whoosh into paddy fields at Yaodou víllage, Xinhua said late Saturday.

"According to witnesses, [they] fell with a 'whoo-ing' sound, lleft j a cloudy streak, then carne crashing down jnto three fields about une kilometre apart, Xinhua said.

"Zhong rushed to the scene, rp- covered two pieces and sent both to Purple Mountain [Observatory] on March 29 with the aid of a frozen-food company, which kept them from melting.

"The largeat chunk, now about the size of a 1 ¡st. left a cráter about one metre in diameter.

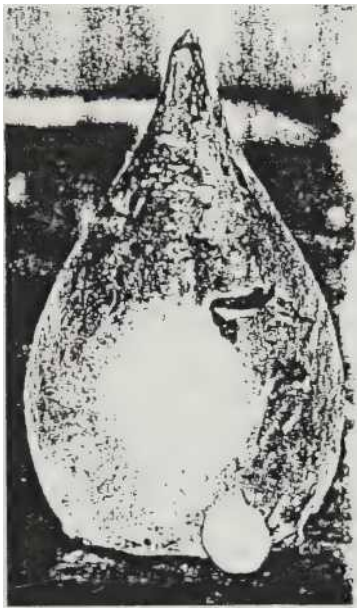
"They are white, semi-transparent, with an irregular shape and what are apparentlv air bubbles on both the sur- face and inside the ice. Unlike manmade ice, the ice has air bubbles, is relatively light and doesn't have the layered structure of haílstones." (R32, R33)

X60. March 1996. EcclesfieJd, United Kingdom. Most of the ice falls admissible to this cntalog are either excessively large or have properties thnt essentially elimínate an aircraft origin. A good example of a prosaic origin for falling ice is a blue color created by leakíng aircraft lavatories. Said color being due to the addition of Chemicals to aircraft toilet water.

The Ecclesfield ice fall is anoinslous not so much for íts lack of the tell-tale blue color but rather for its tear-drop shape. Weighing about 4 pounds {2 kilos), one calculates its volunse as about 2 liters, or approximately the size of two one-quart milk bottles. Teardrop ice masses of this volume defv explanation, especially íf a leaking aircraft aircraft lavatory can be eliminated. (R34)

An outer-space origin. however, is not as easy to rule out. The atmospheric reentry of a large, irregular chunk of space ice could explain the Lcclesfield teardrop. By way of artalogy. we refer to the thp common tearrirop-shaped tekites of Australasia, which were «pparently shaped by aerodynamic forces acting upon droplets of molton rock reentering the earth's otmosphere. (See ESM3 ín our catnlog. Negleeted Geological Anomalies)

Of course, withont more facts and (ideally) **BCÍPO**tifie testimony. one cannot rule out a hoax here,



Photograph of the leardrop-shapeci ice moss íhot reporterily fell in Ecclesfield. I K K. in 199o Weight: ***nbouf*** *4 pcn/mis. (X60)*

X61. July 4 and 15, 1997. Near Campiñas. Sao Paulo State. Brazil. "Two large blocks of ice which ernshed into Brazii's Sao Paulo State from clear skies are believed to be part of a meteor. According to Brazilian researchers. The first chunk weighed more than 110 pounds and tere through the tiled roof of a bus factory July 11 in Campiñas. The second plummeted to the ground July 15 about 37 miles north of Campiñas, causing a small cráter. Offieials at the local air- port ruled out the possibility that the ice may have fallen off passing aircraft as none were in the area when the lwo chunks fell." (R35)

Once agaín múltiple, nearly simultane- ous falls of large ice masses in the same arca. Also, still another roof was an ice chunk's target

X62. July 26, 1998. Rué, Switzerland. "On Sunday July 26, 1998, at «round 9^h45^m Central European Daylight-Savlng Time ($7^h4r>^m$ UT), a Rué furming couple were in front of their house when they

heard a whistling gound ’like a big rocket on August 1' (Swlss national holiday). Thev just had time to see a block of ice the size of a ’footbaU' pass in front of their field of visión and crash into the tsrred path near to their farm. The block broke up into thousands of pieces and the witness recuperated [sicl the lnrgest which was 'the size of a skittle.[1] The ice was 'very hard* and 'snow-coiored.'

"The witness estimated the weight of the ice block at 7-B kg and the pieee he was able to recupérate {sic) at 6-7 kg. Unfortunately, he did not think of conserving the block in the freezer, and let it melt near his house after having shown it to his neighbor, who had also heard the noise."

Swiss aviation officials claimed they could not identify anv aircraft that might have been responsible "because of incertitude over the time of the inciden t".' (R62)

X63. January 2000. Various localities in Spain. The June-2000 ice falls in Spain were numerous and well-observed. Some of the reporta were aiso accompanied by preserved specimens.

This series of ice falls Bttracted the ottention of scientists--------who usually ignore ice-fall anecdotes---------and, in consequence, led to sorious professionel considerntion of the possible r^ality of ice meteorites or "hydrometeors". How- ever, as indicated below, the Spanish "hydrometeors" are not thought to have been of extraterrestrial origin. But how they might have been formed within the earth's atmosphere (assumíng that is really where they originated) is a mejor meteorological mystery.

Our newsletter Science Frontiers followed the story of the Spanish falls with three articles in 2000, 2002, and 2003. These have been edited and re- produced below.

TARGET: SOUTHERN SPAIN [date: 2000] Eurly in January 2000, Southern Spain was bombarded with at least 30 rather large blooks of ice, some weighing 4 kilos (about 9 pounds). Chemists at the l'niversity of Valencia found none of the microorganisrns that would identify the ice chunks as falling off aircraft with leaky toilets. One frozen projeetile hit an autumobile, but the driver was not hurí; another glanced off the shoulder of an elderly woman living in Almería.

As to be expected, the Spanish news- papers played the phenomena for all they could. Also to be expected were a few fraudulent reports. It was all great fun, but scien tifie explanations for the apparently bona fíde hydrometeors are lacking. (R38)

REV1SITING THE SPANISH HYDROMETEORS OF JANUARY 2000 [date: 2002] The hydrometeors we reported above involved about 30 ice blocks in the kilo- gram range. They fell on a sunny day in **Southern** Spain. Happily, some of these large ice chunks were retrieved and preserved by Spanish scientists. Some of the findings have been reported in Science, which is in itself an anomaly, con- siderir.g the scientific community’s riis- dain for events of a Tortean nature.

The analysis of the preserved ice blocks revealed nonc of the eontaminants typical of aircraft lavatories. In faet, no large aircraft were overflying the región when the ice blocks crashed to the ground. Neither were the ice masses extraterrestrial in composition (i.e.; no typical cometary debris or the like).
To all appearances, they were Bimply frozen terrestrial rainwater.

When sawri up. the blocks were seen to be chock-full of air bubbles. Some onion-skin layering also appeared. The contained gases, such as ammonia. and particulates suggested that — despite
their size and the element weather----------
they were just hailstones! But they were certainly not ordinary hailstones and where could they huve come from?

A radical "hailstone" theury has been advanced, based upon the unusually coid and rnoist upper atmosphere present at the time, If ice nuclei existed, say 19 kilometers high, and they took 10 minutes to fall to eorth; it is conceivable that hailstones of the size collected might form. Given the fair weather, tlie only ice nuclei one can imagine would be in the lingering contralla of high-flying jets. These can persist for days.

However, few meteorlogists» are buy- ting the clear-sky hail theory. (R40)

NEVER, NEVER, NEVERü Idate: 2ü03)
G. Fort and his disciples h«ve collected hundreds of reporta of large ice chunks falling from clondless skies. Some ae- counts go back «‘enturies. Such ic e falls, or "hydrometeors,'[1] «re automatically sloughed off by rnairistream rneteorolo- gists. who inevitobly pass them olt as

ice detached frota leaky aircraft luva- tories.

The bombardment oí Spaín in 200Ü by a couple dozen hydrometeors did attract **Borne** sc'ienlific attention. The SpanUh hydrometeors fell frorn storndesa skies, weighed severa! kilos, and had the onion- skin structure of normal hailstones.

Their chemistry was also that of hailstones, not aircraft lavatories. Addition- ally, the presence of air bubbles seemed to rule out sn extraterrestrial orígin.

Now [2003], four years later, we know that hydrometeors are not aiming only at Spain but may fall anywhere — as Forteans have always claimed. Some of the recent, non-Spanish hydrometeors weigh 25-35 pounds and have possessed enough kinetic energy to punch holes in roofs and windshields.

Even so, seientists are reluctant to accept the existence of massive hailstones bombarding the earth in fair weather. C. Knight, a hail expert at the Univcrsity Corporation for Atmo- spherie Research, Boulder, Colorado, is quoted as aaying, ”1 would be tempted to say ’never’ on this." (R42)

X64. January 2002. Charleston, South Carolina. This ice fall, llke so many others, crashed through a roof. The target in Charleston was an Acura car dealership, M. Higgins, the parts-and- service atanager testified as follows:

"’There was a 2j-foot-by-3J-foot piece-----a pretty big slab----------on the floor, with lots of little ehunks,' said Higgins, who added the ice was clear and puré, like normal ice."

The FAA reported that there were no aircraft in the area at the time of the fall, ñor were meteorological conditions conducive to ice formation. (R39)

X65. November 4, 2005. Kent, Washington. The Halte family returned home to find a hole in the ceiling of their daugh- ter’s bedroom Five ehunks of erystal- clear ice lav on Her bed. Hiree were grapefruit-size. Three additional ice ehunks were found in the backyard.

FAA investigators confirmed that the ice ehunks could not have come from aircraft beeause they were not bluish like aircraft lavatory water. (R43)

X66. December 10, 1980. Birmingham, F.ngland. An ice lump weighing 1 pouml.

6 ounces (626 grams) fell into a garden at Kings Norton. The lump was alrnost spherical and had a circumference of 12 inches. No storm in oren mentioned. (R46)

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GWF2 Stone Falls

Descripción. The tal! oi stones, singiy or m showers, larger than coarsest wind- carried sand, (say, more than |-inch in diameter), Most stone falls are reeorded during powerful thunderstorms and often in eonjunction with loud peáis of thunder. The luminous streaks assoeiated with the falls *oí* meteoriies have some- times been reported. Nevertheless, the recovered stones are usually of indisputable terrestrial origin and do not bear the merks of atmospheric reentry.

Background. Such observations are the basis of the discredited thiuiderstone belief. Many ancient peoples believed that líghtningand thunder were accompanied by a míssile, often shaped like an ax head, that was hurled by some supernatural agency. So strong is scien- tific anüpathy towards these supernatural overtones that stone-fall reports are usually re- jected with contempt regardless of their merits.

Data Evaluation. Stone-fall dala are weak. Almost all testimonial. These data are gathered under stressful conditions that encourage distortion and exaggeration. Other phenomena, such as ball Hghtning and ordinary rneteors, have similar c.haracteristics, thus confusing the situation. FLnally, it is always difficult to be sure that recovered stones are not just indigenous rocks that happened to be in the area w'here the phenomenon occurred. Rating: 3.

Anomaly Evaluation. Two kinds of anomaly may be present here: (1) lf the fallen stones are terrestrial in origin and have been picked up by small whirlwinds, the weights of the stones infer higher vertical wind velocity components than gene rally allowed in thunderstorms; and (2) If the stones are meteoric and fall preferentially during thunderstorms, a cause-and- eífect relationship is inferred. Rating: 2.

Possible Kxplanations. (1) The stones are levitated by exceptionally powerful winds during violent storms; (2) The stone falls are hoaxes; and (3) A few may be truly extraterrestrial objects that have somehow escaped the heat trauma of atmospheric reentry.

Similar and Related Phenomena. The similarities of stone-falls and ice-falls (GWF1) cannot be ignored. Both are frequently accompanied by loud claps of thunder and in size greatly exceed the dimensions allowed by meteorology for wind-levitated stones and hail. Some ball-lightning phenomena may resemble those of stone-falls (GLB1 in Remarkable Luminous Phenomena in Nature). Trué rneteorites (AYO in The Sun and Solar System Debris and ESM2/ESM3 in Neglected Geologiced Anoroalies.

Ex ampies of Stone Falla

XI. july 1681. North Atlantic Ocean. The reknowned Arago stated: ' Without having the slightest wish to revive anüquated ideas **rp.garding** thunder-stones, I shall simply rernark here. that it is not proved that we should absulutely regard as false the whole of the narratives, in whicb the fall of vari- ous inatters is related to have accompanied thunder storms. What pretext, for example. is there for considering as untrue the fol JowLng fact. which I extract írom the works of Boyle. 'in July 1681, a thunderstorm produced a great deal of damage near to Cape Cod, upon the English ship the Albe- marle. A flash of Ughtnmg was followed by the fall of a buming bituminous matter into the boat hanging at the ste-rn, which gave out an udour similar to that of gunpowder. This substance was consumed on the spot, and it was in vain that they attempted to ex- tinguish ¡t with water, and to sweep it over- board with a broom. (Rl, R29, R30)

X2. Summer 1846. Richland, South Carolina. A 6 1/2 ounce stone, almost per- fectly round, fell during a violent thunderstorm. The exterior was eoated with a reddish brown glaze; the interior was like firebrick. (R2)

X3. September 1850. Barcelona, Spain. Cónica! stone. Specific gravity: 8. 12. Fell during thunderstorm. (R3)

X4. September 25, 1851. Bornbay, India.

"On the 25ih of September a violent explosión occurred in the air at Bombay, fol- lowed by a wlld rushing sound overhead, heard at various points over an a rea of thir- ty miles in length and eight in breadth, fol- lowed by a severe eoncussion, as if aheavy' body had fallen, just before the occurrence of which a large fire-ball was **seeD** plunging into the sea. " A thunderstorm was in pro- gress. (R4) This account sounds as if a true meteor had fallen during a thunderstorm, eitber through coincidence or some unapprecíated connection between thunder- storms and meteoric activity. Note also that India is also famous for remarkable ice falls (GWF1) and fish falls (GWF9).(WRC) A much more detailed account of tbe X4 fall may be found in R5.

X5. March Ib, 1851. Dhatmab, India. During a heavy thunderstorm, a meteor-like object was seen to fall and hit the ground, with considerable noise. (R4)

X6. April 30, 1851. Kurrachee (sic), India. A violent explosión was heard during a thunderstorm and, about half a minute later, a meteor was seen falling into the sea. (R4)

X7, May[7] 13, 1856. Bremervorde, Germany. "A fall of meteoric stones took place near Bremervorde a short distance from Hain- burg. on the 13th of May last, at 5 o'clock, P. M. It took place during a storm accom- panied by thunder and lightning. A number of stones have been found. One of them weighed nearly 7 lbs., another 3 1/3 lbs., a third two-tbirds of a pound. They were covered with a black crust apparently the eífect of fusión. In the fracture, the stone has a gray color, and shows severa! mineral», among which there is a large quantity of native iron and pyrites. " (R6)

X8. April 29, 1868. Birmingham, England. A violent thunderstorm. "There was an extraordínary phenomenon during the deluge of rain. From nine to ten, meteoric stones fell ıD ¡mínense quantities in various parts of the town. The size of these stones variel from about one-eightb of an inch to about three-eighths of an inch in length, and about half those dimensions Ln thickness. They resembled in shape broken pieces of Rowley ragstone. A similar phenomenon visited Birmingham ten years ago." (R7) Subsequent analysis of the stones conflrmed that they were similar to the Rowley ragstone, a com- mon local formatíon. (R8) The date of this event is given as May 30, 1869, conflicting with R7 and R8. (RIO) The Birmingham fall is a possible case of levitation by a whirl-wind or tomado.

X9. May 25, 1869. Wolverhampton, England. Many pebbles, about 3/4 of an Inch in diameter, fell during a powerful thunderstorm. (R9) Meteoric origin of the stones doubted. (RIO)

X10. June 12, 1858. Birmingham, England. Shower of stones during a violent thunderstorm. (R7, RIO)

Xll. June 26, 1850. Chelsea, England. About 3 p. m., in the midst of many peáis of thunder, one clap was heard which sounded far louder and sharper than the others, and gave one the idea of a eonservatory being shattered. At this time, what appeared like a bali of fire fell on the chimney stack of 180 Oakley Street. The servants sitting in the kitchen were suddenly alarmed by the room being filled with smoke and a heavy black mass falling down the cfumney into the grate, where it appeared to break and scatter fragmenta over the room. They naturally rushed from the room, but as soon as they recove red from their fright, and the smoke had somewhat díspersed, they returned to the kitchen to ascertain what had really hap- pened. Among the debris in the grate a piece, apparently of a ball about 8 or 9 inches in diameter was found, like a cinder with bere and there fragmente of metal inlt." Investigators thought that lightning had per- haps fused material in the grate, (R11-R12)

X12, Circa 1883. Guildford, England. An iron sphere was found at the bottom of a ten-inch-deep hole where lightning had been seen to strike, The hole had char- red sides. (R13) Like so many oíd tales, this one is impossible to evalúate. (YVRC)

X13. No date given. Cantón de Vaud, Switzerland. Stones up to 1 1/2 centimeters in diameter fell. No storm mentioned. (R14)

X14. No date given. Chateau Landon, Switzerland (?). Small calcareous stones 3 centimeters in diameter carried 150kilometers by the wind. No storm mentioned. (R14)

X15. 1883. Sweden. Stones the size of fil- berts enveloped in large ovoid hailstones. The stones were apparently carried 60 kilometers. (R14)

X16. August 1887. Harrowgate, England. Simultaneous wiUi a sharp crack of thunder, a white iight fell to earth. **A** small dense stone was found where the earth had been dísturbed. (R15)

XI í , October 15, 1890. South Pacific Ocean. A bulky mass was seen falling into the

sea during a violent thunderstorrr. (RISi X18. 1892. Hereford, England. A bolt of lightning fell into a yard, leaving a sul- phurous srnell and fragmente of a metal- bearing material. (R17)

XI9. No date given. Casterton, England. "I have frequently been struck by the fact of thunderbolts falling during violent storms, and of their simultaneous appearance with flashes of lightning. That masses of matter occasíonally accompany the electric fluid when il reaches the earth there is no ques- tion; they have been seen and described as 'bails of fire,' and 1 have in my possession one that fell some time ago at Casterton, in Westmoreland. It was seen to fall during a violent thunderstorm, and, killing a sheep en route.buried itself about slx feet below the surface, and when dug out shortly after it was still hot. It appearance it much resembles a volcanic bomb; it is about the size of a large cocoa-nut, weighs over 12 lbs., and seems to be composed of a hard ferruginous quartzite. I have not yet sub- mitted it to a technical analysis, but hope to do so shortly. There is an extemal Shell of about an inch in thickness, andthis contains a nucleus of the same shape and material as the shell, but is quite indepen- den! oí it, so that the one is easlly separa- ted frorn the other; I attribute this separa- tion of the parts to an unequai cooling of the mass," (R18)

X20. July 13, 1909. Gngar, England. "During the severe thunderstorm on the 13th inst. a meteorie stone fell in the stableyard here with a terrifie explosión when within a few feet of the ground, embedding itself in the grave 1 about 8 inches, the ground a round for severa! feet beíng perforated with small holes caused by the fragments. The main part and fragments which we could collect weighed 1 Ib. 13 oz, The fall was wifcnessed by my daughters, who were sheltering about eíght yards away. " (R19)

X21. March 4, 1912. St. Albans. England. During a heavy thunderstorm which unsued on March 4 between 2. 30 p. m. and 4.15 p.m., an aerolito was observed to fall at Coinév Heath, nearSt. Albans. The obser- ver, who has placed the specimen In the hands of Mr. G.E. Bullen, of the Hertfotd- shire Museuni, for examination, statedthat the stone fell within a few feet from where he was standlng, and that it entered the ground ior a distance'of about 3 ft. Its fall was accompanied by an unusually heavy clap of i hunder. The ex ampie, according lo Mr. bullen, who describes it In Nature, weighs 5 lb. 14 1/2 oz., and measures 6 3/4 in. by 5 5/8 in. at its greatest length and breadth respectively. The mass is ir- regularly ovate on the one side, and broken in outline on the other. The actual surface throughout is fairly deeply pitted, andunder magnificatiou exhibits the usual chondritic structure of the crystalline matter, with ínterspersed particles of what appears to be nickeliferous íron. Mr. Bullen has since written to Nature to say that he has since submítted the stone for examination to Dr. George T. Prior, of the British Museum (Natural History), who informs him that it is not of meteorie origin. " (R20, R21)

X22. March 27, 1921. Rome. Italy. (R22)

X23. General observations. A review of the thunderboít theme in literature. No speeific examples. (R23)

X24. General observaban. The concept of the thunderboít is only the childish be- lief of imenlightenod peoples. (R24, R25) X25. General observatior.. Review of the thunderboít theme in Maori folklore. (R26) X2G. General observation. A general history of the thunderboít belief. (R27, R28)

X27. July 17, 1860. Wolverhamplon. F.ngland. A violent rainstoini was accom- panied by "torrents" of so mnny small, black angular stones that shovels liad to be used to collect them. (K31)

X28. May 22 and 23, 1884. Bismarck . North Dakota. About 9 P.M. on the 22nd- and around nooii on the 23rd, pistol-like sounds were heard throughout the city. The sharp noises wer" deter- mined to be due to the fall of small flinty stones. A meteorie origin was pro- posed. (R32)

X29. June 6, 1891. Pel-et-Der, France. A fall of irregularly shaped stones, 2.5-3.5 centimeters in size. The fall covered an arca 50 x 200 meters. (R33)

X30. November 1921-March 1922. Chico, California. One of the most widelv popularizad stone fnlls seems to have been a hoax, although this was never proven. Chico's long series of stone bar- rages inade good newspaper copy and the town's dilemma was widely heralded; even the staid New York Times allowed a few Ítems on tlio months-long phenomenon (R34)

Briefly. beginning in November 1921, this small California t<'wn was pplted with stones whotc source was never

found. The short showers of small stones —some weíghing up tn a pound----------con- tínued sporndieally for sevcral months. Some **Windows** were shattered, but rnainly the stones fell on roofs, damagíng some.

Townspeople searched everywhere for the source, suspecting that stnall boys were bombarding the town. The supposed perpetrators were never found. More likely, it was thought, some hoaxers had rigged up a powerful catapult «nd flung the stones (and occasinnaliy some almonds!) into the town from its out- skirts. (R36) No sucli Bpparatus was ever found despite the many showers over several months of time. (R35)

The Chico stone showers were real enough. A poltergeist was suggested; **some** spiritualists called thern "apports" (things that materialize out of nowhere). Most, however, bet on hoaxers. In any case, the showers «topped suddenlv in March 1922. To our knowlodge, they have not recurred.

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GWF3 Sulphur/Pollen Falls

Description. The fall of a yellowish substance in chunks. in the lorm of dust, or in yellow rain. On rare and questionable occasion6, the substance has been said to be burning as it fell. In other circumstances, the collected matter can be bumt and seems to have some of the properties of sulphur. Most often, though, the fallen material is quickly identified as pollen, particularly pine pollen.

Background. Sulphur/pollen falls bring to mtnd the Biblical falls of fire and brimstone. In- deed gome sulphur/pollen falls have been linked wlth the immlnent end of the world. As in the case of thunderslones, scíentists have gone out of their way to deny the possibility of sulphur falls, blaming all such phenomena on pollen falls. A few cases do not yield to this explanation so easily. We present these here along with a few run-of-the-mill cases of mísidentified pollen falls.

Data Evafuation. The data supporttng the reality of true sulphur falls are oíd and very weak. The eye-witness accounts are oíd and shaky; the purported Chemical analyses are presented without adequate detail. Rating: 3.

Anomaly Evaluatlon. The fall of free sulphur, which ís rarely found in sur face deposits where winde could plck U up, would seem to be very unlikely although not impo6sible. Vol- canic erupüonB mlght also contribute sulphur. A significant anomaly would be posed only if the remarkable tales of falls of burning sulphur were true. Overali rating: 3.

Possible Explanations. It cannot be denied that almost all so-called sulphur falls are really pollen falls. Yet, as mentloned above, real falls of free sulphur are definitely not impos-sible-----just improbable. Falling, burning matter might conceivably be meteoric. (See X8, for example.)

Similar and Related Phenomena. Rain colored other than yellow (GVVP10). Dust falls with various hues are so common and well-understood that they are not included in this Catalog. Exceedingly rare are reports oí falls oí other types of burning materials (GWF2-X1). Bal] and bead lightning on occasion seem to leave behind residues of burning material (G1.B and GLL23).

Examples of Sulphur/Pollen Falls

XI. June 1642. Magdeburg, Germany. Burning lump of sulphur the size of a man'e fist. (117) Too large to be pollen? (WRC) X2. May 16, 1646. Hasnia, Italy. Heavy rain leaves sulphurous powder. (R17) This is a more typical observation. Pine pollen is the usual verdlct. (WRC)

X3. March 1832. Kourianof, Russia. "In March last, there tell in the fields oí the village of Kourianof, thirteen versts from Wolokolamsk. a combustible substanre uf a yellowish color, at least two inches thick. and covering a superficies of between si.x and seven hundred square feet. The inhabi- tants, at first, thought it was snow, but on examination. it appeared to have the properties of cotton, having, on being tora, the same tenacity; but, on being put into a ves- sel full of water, it assumed the consistency of rosin. On being put into the first, in its prirnitive State, it burnt and sent fortl) a fíame like spirits of wine; but in its resin- ous State, it boiled on the fire. without he- coming inflamed, probably because it v* js

mixed with some portion of snow, from which it had been taken. After a more minute examination, the rosin had the color of amber, wa* elastie like indian (sic) rubber, and smelt lLke prepared oil, mixed with wax. " (R2) Obviously, one eannot do much with a datum such as thís, but the time of year and reported properties militate against the pollen theory. (WRC) Item fírst pubíished in R1.

X4, Jone 1841. Pictou, Nova Scotia, Cana- da. Yellow matter fell on a vessel in Pictou harbor. Swept up by the buckets- full, Examjnation proved it to be pollen. (R3)

Xf>, 1850. Napoleón, Arkansas. Rain had the appearanee of liquid sulphur and left a thick scum on surfaces. Pollen sus- pected. (R4)

X6. October 18, 1867. Thames Ditton, Eng- land. ' The inhabitants of the village of Thames Ditton, Sur rey, were, on Frlday night, October lSth, 1867, a good deal star- tlea at witnessing a very strange phenome- non, which had the appearance of a shovver of fire. The shower lasted about ten minutes, and during its continuante aiforded a brilliant light. Next morning it was found that the waterbutts and puddles in the upper part of the village were thickly coveredwith a deposit of sulphur. " (R5) Pollen would hardh burn while falling, but neither would partióles of free sulphur. (WRC) Seealso X8.

X7. February 14, 1870. Genoa, Italy. A re- markable rain of yellowish matter that proved to be pollen. (R6)

X8. June 17, 1873. Proschwitz, Austria. "U is remarkable that perfectly authentic statements were received of the deposition, soon after, or about the time of, the meteor's explosión over Zittau and its neighborhood, of a mass of melted and burning sulphur the size of a man's fist, on the roadway of a village, Proschwitz, about 4 miles South of Reichen- berg, where the meteor exploded nearly inthe zenith. it was stamped out by a crowd of the villagers, who could give no other explanation of its appearance on the spot other than that it had proceeded from the meteor; on examination at Breslau some remnants of the sub- stance proved to be puré sulphur. " (R7)

XU. Apríl 18, 1883. lowa. An abundance of pine pollen was found floating on a pond. Pines in nearby forests not in bloom, so the pollen must have travelled at least 300-400 miles. (R8)

X10. May 12, 1886. Munich, Germany. Heavy rains cover pools and streamswith a yellow matter. Jx>cal populace thought it was sulphur and betokened the end of the world. Scientísts identified it as fir pollen. (RIO)

XI1. March 4, 1892. Baleario Isles. A vio- lent north wind brought a rain that cov- ered the ground with a yellow coating that proved to be sulphur. (RIl)

X12. April 13, 1894. Adissan, France. (R12)

X13. March 21, 1898. Mount Vernon, Ken- tuckv. A eupposed sulphur fall. The fallen substance burned and gave off sulphur-like fumes. Editor of journal insiste it must have been pine pollen. (R13) X14. June 1, 1902. England. (R15)

X15. May 4 and 21, 1908. Orleans. France. (R16)

X16. General observations. The so-called "sulphur rains" are nothing more than pollens falls. (R9) Except where real sulphur may te blown from voléanos. (R14)

X17. General observations. "Pollen of vari- ous plants, as previousiy noted, is one of the most commun con6tituents of atmospheric dust; for instance, Miquel found that there are often a thousand pollen grains to each eubic meter of air. But pollen deserves more extended notice because it is really shuwers of pollen that have been so often reported as showers of sulphur. The y ellow color sug- gested sulphur; pollen, espeeially of pine, is highly inflammable, the imaginalion sup- plied the smell of brimstone, and supersti- tion jumped at the conclusión that the devil had been busy. The occasional phosphores- cent appearance of pollen falls at night also has encouraged preternatural speculatiens. " (R18)

XIS April 11, 1632. Europe. 'This substance fell from the sky on the llth April, 1832, 13 werstes from the town of Woloka- lamsk, and eovered to the thickness of 1 to 2 inches a space of S to 10 square rultres.
It was of a wine yellow, transparenL, Soft, and smelling like rancid oil. Its sp. gr. was 1.1. It melted in a cióse (sic) vessel, and yieldéd the commun producís of vegetable substances, leaving a brilliant char- coal. It burnt with a blue fíame, without smoke. It is insoluble in coid water, but melts in botling water, and then swims on the fluid. Boiling alcohol dissolves it. It dissolves also in carbonate of soda, and the acids sepárate from the solution a yellow viscous substance, soluble in coid alcohol, and which contains a peculiar acid." <R19)

Next 10 pages duplicated in all copies. Nothing ¡s missing.

Ex ampies of Falls of Manna

XI. 1824. Persia. Ground covered in some regióos by edible llchens, called manna.

<R1>

X2. 1828. Persia. Edible substance saidto fall from lhe sfcy. 'It occurred in sueb abun- danee that lhe ground was of a sudden entire- ly covered by it over a great extent. In soroe spots it was five or six inches deep. It was ealen by cattle, and particularly sheep;and bread wᶠas made of it, which afforded nour- ishment to man. Such were the accounts furnished to the French Cónsul in Persia, by a Russian general, who was an eye-witness. ” (RI) The fallen substance was later identi- fied as the plant Par me 11 a esculenta. (R2,
RIO) This classic example said to occur in 1829. <R3)

X3. Spring 1841. Lake Van, Turkey. The ground was covered tu depths of 3 or 4 inches by a gray, granular substance that was pleasant to the taste. Bread was made from it. <R10)

X4. JaDuary 1846. Jenischehir, Turkey. Edible substance falls during a time of fa- mine. "It lasted some davs, and the pieces of lichen were of the síze of hazel-nuts.
They were ground into flour, tbe bread from which was pronounced little inferior towheat bread. Another account says that the manna was of greyish-white colour, rather hard and irregular in forro, inodorous and insi- pid." (RIO, R17) Another report puts this fall in April 1846. (R3)

X5. April 18, 1848. Byazíd, Turkey. Edí- ble licbens said to have fallen from the skies. (R4)

X6. July 1864. Diarberker, Turkey. Manna appeared. Said to be lichen. {R5, R6)

X7. Circa 1887. Turkey. The followingdes- cription was provided by a Mr. Colé, an American missionary. "We travelled for four days through a región where had newly fallen a remarkable deposít of heavenly bread» as the natives sometimes cali It— manna. There were extensive forests of scrubby oaks, and most of the deposit was on the leaves. Thousands of the poor peas- ants, men, women, and children, were out upen the plains gathering the sweet sub- stance. Some of them plunge into kettles of boiling water the newly cut branches oí the oaks» which washes off the deposit until the water becomes so sweet as to remind the Yankee of a verítable sugaríng off intbe ₀Jd Oranite State as he takes sips of it, Other companios of natives may be seen vigorously beating wilh sticks the branches, that, hav- ing been spread on the ground, have so dried that the glistening crystals fall readiiy upon the carpet spread to receive them. The crystals are separated from the pieces of leaves by a sieve, and then the manna is pressed into cakes for use. " (R8)

XS. August 1890. Diarbekir(sic), Turkey. "The director of the central dispensary at Bagdad has sent to La X’ature a specimen of an edible substance which fell during an abundant shower in the neighbourhood of Merdin and Diarbekir {Turkey ín Asia) in August 1890. The rain which accompanied the substance fell over a surface of about ten kiiometres in circumference. The ín- habitants collected the ’ manna» * and made it into bread, which is said to hav» been very good and to have been easil’ Jigested. The specimen sent to La X[1] ature ís composed of small spherules; yellowish on the outside, it is white within. Botanists who have ex- amined it say that it belongs to the familyof lichens known as Lecanora esculenta. " (R9)

X9. General observations. Sinai, Egypt. An expedition from the Hebrew Univer- sity was sent out to determine the true nature of the Bíblica] manna. It found that two scale inseets in the región excreted a citar, sweet fluid that cry- stallized into graíns and fell to the ground from the trees. (R16)

X10. March 1900. Chanaa, India. During a great famine, bambeo trees exuded a tvpc of edible mirona. ÍR13)

XII. General observaron. "Our Cónsul in Jerusalem States tiiat manna is found novio the regions .>/ upper Mespotamia and Kur- distan and along the Persian frontier. It falle, he says, ín the form of dew- during Seplember, October, and November, and lodges upon the leaves of oak trees. It ¡m* raed i ate ly hardens and assumes the forra of a grain. Early in the momíng before the heat of the day it is gathered by spreadíng sheets beneath the trees, which are shaken, and the manna is then collected and storod for winter to be used as a food or shippedto Bagdad for sale in the bazaar. The manna falls on other vegetation, including the grase, but all of lt is lost e\cept that which is gathered from the oak leaves. The manna is sweet and is caten by the natives as a substi- tute for sugar or honey. " (Rifo Such wide-spread occurrences would setin to indícate that the manna it- not the product of a speci- fic tree. See X12 and XI3.

XI2. General observation. A kind of manna Ls produced by tbe linden in Europe. (R?) X13. General observations and controversv. No agreement reached on whether the manila of the Israelites was lichens or a product of the tamarisk tree. (RIO, Rll. R12, R141

X14. General observations. "An account of manna 'rains' certainly pertains to the dis- cussion of showers of vegetable niatter, for the substance manna consists of lichens of the genus Lecanora, but in none of the nu- rnerous recordad instances of manna'rains' is there any direct etüdence that the sub- stance really fell from the sky. These lic- hens form, small, round bodies that are easily blown over the surface of the ground and a», cumúlate in depressions; they are ver} buoyant also and henee easily drifted into masses during the run-off of rain water. Manna 'rains' have not occurred except in eountries where these lichens are common, and as for statements of their falling down upon roofs or upon people, or for any other proofs that they really rained down. I have seen nene." (R18)

Xl5. General. North Africa, Middle East, Southwest Asia. The edibility of lichen6 and the many tales of manna were ad- dressed briefly in a 1971 technical book by J.H. Bland riedicated to mosses and lichens In general. Bland wrote:

"The M8nna Lichen (Lecanora excu- lenta), a desert species óf Crusty Lichen, probably fed the Israelites in their plight in the desert. It is stíll eaten by desert tribes, who mix it with mea! to one-third of its weight and make it into bread. In Southwest Asia, it is used as a substitute for corn." (R20) Wíndstorms can sweep up loosely attached lichens and deposit thern else- where to provide one basis of "falls of manna."

"In receñí times a remarkable deposit of lichens occurred in Mesopotamia during a sudden hailstorm. When the hail melted, the ground was covered with lichens; speciemens were sent to a scientist named Errera who identified thern as Lecanora culenua. His opinión was thai two klnds of manna are re- ferred to in the Bible; in one case (Exo- dus XVI: 4) it is the sweet gum of the tamarisk, o graceful evergreen shrub or small tree, with slender, feathery branches in Southern Europe and western Asia, the other kind (Numbers XI:7-9) plainly refers to the lichen." (R20)

X16. August 1980. Hawley, Pennsyl- vania. On an early summer pvening, p7w7 Becker. a census taker, was sil- ting ín his car Consulting a map. The car was parked on a dead-end streel. No people or other ears were in sight.
Becker reported:

"Suddenly there wns a horrific bang Bnd the car rocked, A missile from the the sky lay in plain view, square in the center of my car's hood.

"1 eautiously got out to examine the fallen object. Tiny pieces had broken off, but it was largely intact and mea- sured four to five inches across. I smelled it—yes, it stili carried a faint scent----of pizza! It was a slice of pizza, solid as o rock and stone coid. This was no ordinary meteorito. I thought of God feeding the Israelites manna from heaven, but God knows 1 profer pepperoni. This was plaín, tomate and cheese. on a thin cruet. (R21)

Who said Science does not have its humor?

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GWF6 Unusual Falls of Hay and Leaves

Description. The fall from a olear sky' or with normal preeipitation of large quantities of hay or dead leaves. Many of these falls begin at great heights and may continué for hours. The sources of Lhese malerials may be miles from the place-of-fall. A curious feature of this type of fall Is the apparent lack of debris among the hay or leaves and, in tbe latter case, the presence of only one type of leaf.

Background. Vlrtually every country lad has seen cut hay suddenly whipped aloft by whirl- winds and deposited on roofs and telephone wires. The falls meriting mention here are notable for the heights involved, great quantities of materials, long distance of travel, and long duration of fall.

Data Evaluation. This phenomenon is well-documented in the older literature. Rating: 1.

Anomaly Evaluation. This phenomenon, as defined above, is merely an extreme case of well-known pranks of whirlwinds. The only possible mystery is the high selectivity of the transporting agency: i.e., the lack of debris and more than one species of leaf. Rating: 3.

Possible Expíanation. Whirlwinds and tornados.

Similar and Related Phenomena. Other falls in the GWF section, especially GWF10 and GWF11 where the falls are usually devoid of other animal species and also the natural debris (plant matter, etc.) that one would expect from an animal's habitat.

Examples of Unusual Falls of Hay and Leaves

XI. Circa 1845. England. Quoting a letter from Sir John F. W. Herschel. ’’In the hay season, some three or four years ago, the day being clear and hot and calm (at least in the immediate neighbourhood of our house), our altention was excited by what first seemed to be strange-looking blrds flying; but though presently assured they were not bírds, it was by no means clear what they were. They were irregular wispy maeses salling leisurely up and settling down again, apparently over a hay field on the east of our grounds, and about aquar- ter or three-eightbs of a mlle from our house. Some of these were of considerable size, and their general appearance was convex downwards and taily upwards. After wondering awhile, I got a telescope and di- rected it to the flying phaenomenon when it became evident that they were masses of hay----some of very considerable size, cer- tainly not less (allowing for the distance) than a yard or two in diameter. They sailed above leisurely, and were very nu- merous. No doubt wind prevailed at the spot, but there was no roaring noise, ñor any sign of a whlrlwlnd, and all about us_ was quite calm." (RI)

X2. September 1861. Putney, England.

ClumpB of hay fell from great heighls.

(R2)

X3. July 27, 1875. Monkstown, Ireland. "About half-pdst nme o'clock thís morning, as I was standing at a window facing east, in Monkstown, my attention was called by the Rev. T. Power to a number of dark floeeulent bodies floating slowly down through the air from a great heíght, appear- iag as if falling from a very heavy, dark cloud, which hung over the house. On go- ing to the hall door, a vast number of these bodies were discerned falling on aJl sides, near and far, to as great a distarme as theír size permitted them to be seen—- over an area whose radius was probably between a quarter and half a mile. Pre- sently, several of these flocks fell cióse to my feet. On plcking up one, it was found to be a small portion of new hay, of which 1 endose a sample. When it fell it was as wet as if a very heavy dew had been de- posited on it. The duratíon of this phenom- enon, from the time my attention wasfirst called to it till it had entirely ceased, wa6 about five minutes, but how long it may have been proceedíng before this I cannot tell. The flocks of hay, from their loose, open structure, made a large appearanee for their weight, but the average weight oí the larger flocks was probably not morethan one or two ounces, and, from that, allsízes were perceptible down to a single blade. There was no rain from tbe dark cloud over- head, though it had a particularly threatening appearanee at the moment of observation.
The air was very caim, with a gentle under-current from S. E. The clouds were movtng in an upper-current from S. S. W. " (R3, R4, R5, RIO, R12, R17)

X4. June 17, 1884. England. LKirlng fine weather, considerable hay passed over-head. Some fell, but some arxnful-sized bunches sailed along untíl out of sight. (R6)

X5. July 26, 1891. Boraston, England. ”We had a curious sight from this house yester- day. It was a dead calm, but in a field just below the garden, with only one hedge between us and it, the hay was whirled up high Into the sky, a column connecting above and below, and in the course of the evening we found great patchea of hay raining down all over the surrounding meadows and our garden. It kept faJling quite four hours after the affair. There was not a breath of air stirring as far as we could see, excepl in that one spot." (R7)

XG. June 30, 1897. Belchamp Sí. Paul, Eng land. A whirlwind carries hay out of sight at Halstead. It falls (apparently) at Belchamp St. Paul, 3 miles distant. Some of it was in large bunches. (R8)

X7. June 7, 1906. Sprimont, France. A cloud of hay obscures the sun. (R9)

X8. July 31, 1920. Stone, England. Wisps of wet hav, larger than dinner plates, fall. (Rll, R19)

X9. June 28, 1931. Spa, France. (R13)

X10. October 1889. Dumfriesshire, England. "I was struck by a strange appearanee in the aimosphere, which I at first mistook for a flock of birds, but as I saw them falling to the earth my curiosity quickened. Fixing my eyes on one of the larger of them, and running about 100 yards up the hi 11 until di- rectly underneath, I awalted lis arrivai, when 1 found it to be an oak leaf. Looking upwards the air was thick with them, and as they descended in an almost vertical direc- tion, oscillating, and glittering in the sun-shine, the speetacle was as beautiful as rare. The wind was from the north, blow- ing a very gentle breeze, and there were oc- casional showers of rain. On examination of the hills after the leaves had fallen, it was found that they covered a tract of about a mile wide and two miles long. The leaves were wholly those of the oak. No oak trees grow in clumps together nearer than eight miles." (RJ4) Same incident placed in 1890. (RIO)

XIJ. April 7, 1894. Clairvaux, France. It rained dead leaves for half an hour. (R15)

X12. April 1, 1900. Wallingford, England. "At about four o'clock on the afternoon of Sunday last (April lst), my attention was arrested by the fall of numbers of dried beech leaves. On looking up I found that the leaves were passing in large numbers from east to west, and as high as the limit of visión. Many appeared to be mere specks, whose height and motion promised them a journey of some miles at least. The shower continued for perhaps twenty minutes. The fall was noticed by many persons here, who were unable to account for it, as there are no beech trees within two miles at nearest. Probably the leaves had been ralsed by a whirlwind, and at a very considerable dis- tance east of thís neighborhood." (R16)

X13. Auguat 17, 1883. Asrao, Switzer- lend. On a windless day, clouds aiter- nating with sun, a delnge of hay rained down on this Swiss town. The -italks

eovered roofs, trees, rosds, and gar- dens. The clumps íell slowly, like SHOW.
A seemingly infinite number of long stalks could be seen at great heights among the elouds, whieh were drifting north. The high-eititude flight uf hay persisted for 3 hours, (H18)

XI4, April 19, Blois, Trance. The wind nt the surfacp was calm when leaves bogan raining down in quantity from a slow-moving cloud hundreds oí tneters above. The leaf fall lasted for 6 hours. (H19)

X15. July 28, 1992. Essex, England.
''The mystery downpour started after lunch yesterday, with eyewitnesses claiming to hBve seen large lumps of straw falling from hundreds of feet up.
"No rational explanation could be offered by sceptical Met Office spokes- man Barry Park.
"Mr. David Jenkins of Commonhall Lañe said: 'There were large handfuls of straw, like you would put in a rab- bit hutch, falling out of the sky.'
"Mr. Jenkins, who is retired, added: 'There were hundreds and hundreds of them. they must hBve been whipped up by the wind or something."'
Mr. Paul Moore of Hall Crescent claimed to have seen hundreds oí lumps from the size of a quarter bale falling from 1,000 feet up, looking as if they had dropped from a cargo plañe, and clumps of **straw** were in the trees of nearby John Burrows recreation ground where they landed.
A baffled Mr. Park at the London Meteorlogical Office said although tor - nodoes or even dust devils could pick up straw, weather conditions were un- suitable and could not lift up the amount described to such great heights. (R20)
Once ngain, it is the total quantity of straw. the large lumps, the great heights ínvolved, and the slow rotes of descent that impress the anomalist.

XÍ6. July 1994. Wooburn Grecn, United Kingdom. In mid-July, about 10 ton? of hav fell on Wooburn Oreen. Some lumps werc as large as bales. They seemed te float down gently, like balloons, to tb*- ground. A larga «rea surrounding the town was eovered. (R21)

X17. July 22. 1997, South Moltnn, United Kingdom. About 3:30 P.M., F. ílolcombe was sitting in his garden "when a large clump of hay about the size of a football landed next to him. He was bewildered as to where it had come from and looked up into the sky and saw that it was full of hay of different size lumps as far up as the elouds." There was no wind at the surface. (R22)

X18. August 1999. Lincolnton, North Carolina. Leaves from cora stalks up a yard long fell from great heights in many parts of Lincolnton. The weather was fair. WInds were light. No thunderstorms were in the area. (R23)
How did the corn leaves become de- tached from their stalks? Usually, stalks and leaves are ground up together for ensilage.

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GWF7 Gelatinous Meteors or Pwdre Ser

Description. The fall of gelatinous masses, usually accompanied by luminous phenomena, The substance is soft and jelly-like, odiferous, and has a tendeney to evapórate away rapidly. Gelatinous meteors range from a few inches to four feet in diameter according to reports.

Background. The idea that offensive masses of jelly-like substance can fall from the sky is fírnily entrenched in folklore, as confirmed by many colorful ñames, such as pudre ser (a Welsh terxn, more correctly spelled pwdr ser), star shot, rot of tile stars, etc. In the ex- amples that follow, the reader will find two different phenomena eonfused: (1) The observed fall of something from the heavens; and (2) The discovery in fields of gelatinous masses.
The lalter phenomenon possesses a simple biological explanation--------assuming the mass did not fall. The actual fall of jelly-like substances admits to no easy solution, assuming its reality.

Data Evaluation. With few exceptions, the observations of gelatinous meteors in flight are oíd and rather shaky. Many examples profferred as cases of gelatinous meteors are weak- ened by the strong possibility of misidentification and coincidence; that is, one sees a luminous body descend nearby, searches the next morning, discovers a gelatinous mass in the general dírection of the visual phenomenon, and calis it a gelatinous meteor. Meteor iro- pact points are easily misjudged, and natural gelatinous masses seem rather common in fields. Nevertheless, many cases cannot be eliminated easily, and there is much internal consistency. Rating: 3.

Anomaly Evaluation. The confirmed descent of gelatinous masses from outer space would constítute a significant anomaly, for (quite obviously) they do not fall into any recognized class of meteorítes, Raling: 2.

Possible Explanations. Most of the so-called gelatinous "meteors" are most líkely just terrestrial substances, such as plasmodia, decaying fungí, water-swollen and distorted animal recnains, and even man-made materials. Truc gelatinous meteors/ meteorites, if they exist, have no easy explanation.

Similar and Relatad Phenomena. Animal falls (GWF10-14); signs of extraterrestrial life in meteorites (panspermia theory).

Exampies of Gelatinous Meteors

Xl. October 23, 1638. Dartmoor, England. A thunderstorm of great extent and fury. A ehurch was struck and vvrecked by líght- níng. A loatbsome odor accompanied the phenomenon. "It seems that some person vvbo ventured to go up inte» the wrecked tow- er, there discovered ’a round patch as broad as a bushel, which looked thick, slí- my, and black, to which he put his hand, and found it soft, and bringlng some from the wall, carne down and showed thatstrange compound. It was like a slimy powder, tem- pered with water; he smelling thereto, it was odious beyond expression, and in a far higher degree of loalhsomeness than the scent which was in the church when they first smelt it, being of the same kind, ’ and the discoverer was shortly after attacked with severe colic." flR20)

X2. March 24. 1718. Isle of Lethy, India. Gelatinous matter fell along with a bail of fire. (R3, R5)

X3. Mareh 8, 1796. Lusatia, Europe. A viscous matter fell with a meteor. It had the color and odor oí varnish. (R3, R5)

X4. January 23, 1803. Silesia, Germany. A meteor fell with a whizzíng sound and seemed to lie burning on ground. Caí the next day a jelly-iike mass was found on the snow.

X5. August 13, 1819. Amherst, Massachu- setts. "On the 13th of August, 1819, be- tween eigbt and nine o'clock in the evening, a fireball, of Lhe size of a large blown blad- der, and of a brilliant white light, was seen in the atmosphere. It fell near a house, and was examined by Rufus Graves, esq. former lecturer of chemístry at Dartmouth College. It was of a circular form, resembling asoiid dish, bottom upwards, about eight inches in diameter, and about one in thickness, of a bríght buff colour, with a fine nap upon it, similar to that of milled cloth. On removing this nap, a buff-coloured pulpy substance.of the consistence of soft soap, appeared, hav- ing an offensíve suffocatmg smell, producing nausea and giddiness. After a few minutes exposure to the air, the buff-colour was changed to a livid colour, resembling venous blood. It attracted moisture readily from the air.'[1] (Rl, R2, R13, R31) Probably the observers just thought they saw the meteor land wbere the jelly waa found, and that they aotunlly found only o terrestrially-produced plnsmodium. (R19)

X6. November 13, 1833. Rahway, New Jersey. During the incredible meteor shower seen over much of the eastem United States. People saw a fiery rain and upon examínation discovered lumps of jelly. (R6)

X7. November 13, 1833. Newark, New Jersey. A mass of gelatinous matter, like soft soap, was found after the great meteor shower. Forcé of ímpact disturbad the ground. Subslance evaporated readily when heat was applied. (R6)

X8. November 13, 1833. West Point. New York. Woman sees a round, flattened mass, the size oí a coffeecup, fall. It was transparent and quickly evaporated. (R6)

X9. 1830s. Lincoln, England. Man sees a meteor fall in a field, found nothtng but a lump of jelly. (R14)

X10. October 6, 1844. Coblentz, Germany. .a Germán gentleman (a friend of Mr. Greg’s), accompanied by another person, late ín the evening, walking in a drv ploughed field, saw a luminous body descend straíght down cióse to them {not 20 yards off), and heard it distinctly strike the ground with a noíse; they marked the spot, and returning early the next morning as nearly as possible where it seemed to fall, they found a gelatinous mass of a greyish colour so visrid as 'to tremóle all over' when poked with a stick. It had no appearance of being organic." (R9)

Xll. November 11, 1846. Loweville, New York. ",. .the most remarkable meteorever seen In that section made its appearance from tbe west. It appeared larger than the sun, íllumined the hemisphere nearly as light as day. It was in sight nearly five minutes and was vvitnessed by a great num- ber of the inhabitants of the village, and fin- aily fell in a field in the vicinity, and a large company of the citizens immediately repair- ed to the spot and found a body of fetid jelly, four íeet in diameter." (R7)

X12. 1914. Ruesia. A brilliant cigai— shaped object crossed the sky, An unpleasant jelly-like substance fell near the house of a peasant, It evaporated in several hours. (R22) (Attributed to Znannya ta Pratza. no. 1, 1967.)

X13. February 3, 1980. Hemel Hempstead, England. "Mr. Philip Buller found lumps of a colourless gel lying cióse together on his lawn. The lumps lay so near to one another that their common origin was nol in doubt. The total volurne was consídered to be ap-

proximately sufficient to fill a yogurt cartón, say 75 mi.” A sample submitted for analysis was thought to be of amphibian ori- gin and perhaps regurgitated by some preda- tor. (R26)
X14. No date given. Wales. A mass of jelly fell on a man working in a field. Nostorm or luminous phenomena reported. (R13) X15. No date given. Loweli, Massachusetts. A man bees a brilliant sbooting star fall to earth near him. Upon Investigation he found a jelly-like mass with an oífensíve smell. (R16)
X16. Table of "doubtful” meteorites. Falis of viscld matter witb luminous meteors reported in the years 850, 1110, 1548, 1557, 1652, 1686, 1718, 1796, 1811, 1819, 1844. (Since no details are given, and the observations are said to be questionable. no sepárate entries are provided. WRC) <R8)
X17. General observations. The analysis of substances found in a field and thought to be gelatinous meteors were found to be of animal origin and similar to snail jelly. (R4) The source of pwdre ser observations is probably the Tremella Nostoc, a jelly-like substance seen in wet places. (RlO)Jelly-like masses, called 'pwdre ser' in Welsh, are fre- quently mentioned Ln literature and often associated with luminous phenomena. (R12) The jelly-like masses found in the fields are undoubtedlv plasmodia of a myxocete. (R15, R18)
X18. General observations. Gelatinous masses found in fields may be food dis- gorged by herons. Such matter may sometimes be luminous. (R18) These masses are probably the viscera of toads and frogs that have become swol- len with xnolsture. Herons may disgorge such matter and other predators maydis- embowel frogs and toads before consum- ing them. (R21)
X19. 860. Ralch. Germany. (R27) See dis- cussion under X22.
X20. 1406, Lucerne, Switzerland. See dis- cussion under X22. (R27)
X21. 1548. Mannsfeld, Germany. (R27)See discussion under X22.

X22 1557. Sehlage, Germany. "These cases were first observed some time after they were believed to have fallen from the atmosphere upon the earth; and it henee rematas doubtful whether they were everinthe atmosphere. Meteorlc stones, indeed, sug- gest mdications of atmospherical formation, but these gelatinous masses point out no »n- dications of the kind. Indeed botanistfi them- selves are al variance with philosophers about the matter of shot-stars, which is commonly colourless, and the Tremella meteorica, which Meyen recently describcd as Actinomyee. may be readily taken for a shot-star, if both are generally capable of being diseriminated. It may be conceived that this ís not necessary, and that themete- oric mass might assurne the organic and vegetable structure. To this it may be ob- jected, that the specimens of Tremella meteorica, are frequently found of different sizes, without it being probable that they are remains of a shot-star, especially where they are smali, and, as is commonly the case, occur attached to animal bodies, and even incurporated with them. It is there- fore improbable that ít is sometimes formed terresirially and sometimes meteorically, because the body exhibits tuo lttle charac- teristic peculiarity to owe its origin to cir- cumstances so very dissimilar. Besides, this supposes that the sudden origin of organic bodies Jrom unorganized materials may be proved. As to the two cases oí Lucerne and Mannsfeld, it is to be remem- bered, that, in the latter case, the blood- spots found on the soil, on the moming after ihe appearance and **explosión** of a fire-ball, admit of a very simple expianation, that, in searching for something extraordinary, as the sign of a mass that had fallen, another fungus was found, the Telephora sanguínea, which Agardh calis Palmella cruenta; and which, on accounl of its entirely superficial extensión on moist ground, and from its strikmg coiour, exhibíted completely tbe appearance of spots of blood. The thick gelaninous masses of both the other cases is distinguished from the usual matter of shot-stars, the Tremella meteorica, by their red coiour. It would therefore be of importance to examine whether similar ap- pearances are any thing else than this, with a particular difference of coiour; whether they are definitely marked by a peculiar structure; or whether, in the absence ofany structure, ít can be perceived to be an in- organic meteoric concrement,--------a matter hitherto undecided.” (R27)

X23. June 23, 1978. Cambridge. Englaud. "I wonder if you could tell me wbat the sub- stance was that alighted on my lawn during a very heavy rainstorm last Friday evening (23 June). It glided down about the size of a football and settled like a jelly. It was white and gloy-like, but cellular. It didnot appear to dísintegrale, but had completely disappeared by the morning. I carne down

north-south. " This observation was subse- quently confirmad in writing by a neighbor. (R23)

X24. August 11, 1979. Frisco, Texas. "Two purple blobs that Síbyl Christian iound on ber front lawti have defied analysis by space sci- entists, who say they haven't ruled out the possibility they could be a rare form of me- teorite. 'It's kind of llke a pium pudding,' according to Doug Blaochard, a geochemist at the National Aeronautics and Space Ad- ministration near JIouston. 'It has round, solid chunks in it that remain after the goo goes away. We don't know what it is,' he said yesterday. " (R24) "The inysterious purple blobs found in a yard in this North Texas town and tu raed over to the nation's top space scientists for study are the cherai- cad leftovers of a battery reprocessing plant, a Texas museum official says. And officials at the National Aeronautics and Space Admín- istration say it looks like the museum official is right. " (R25)

X25. Poetic references. Somehow, poets of i he last few centuries could not re- sist inserting star jelly (or pwdre ser) into their lines. From the many examples, we quote just two.

From Cowley:

"So stars appear to drop to us from sky,
And gild the passage as they fly;
But when they fall, and meet th' opposing ground,
What but a sordid slirne is found."

From Suckling:

As he, whose quicker eye doth trace
A false star shot to a market place Doth run apace,
And thinking it to catch,
A jelly up does snatch.

The point here is that the association of shooting stars with terrestrial lumps of jelly-like substances was deepíy en- grained in the human mind not too long ago. This fact is emphasized again in the next entry ((X261. Of course, the poems and folklor** only hint at n causal con- nection hetween a falling slar and a jelly, they cannot prove the reality of this iincíent claimed phenornenon.

X26. folklore references. Star jelly, in all itsHmany ñames, has pervaded the folklore of Europe ovrr »he ages. A 1984 review oí belief in this scientiíicaliy unlikely phenornenon, by H. Belcher and E. Swale. concludes with 102 references. The range of their literature search was immense. The reason for the ubiquity and longevity of belief in star jelly is probably due to the large number of apparent coincidences on record of ob- servations of shooting stars followed by immediate discoveries of jelly-like masses nearby.

Belcher and Swale devote most of their article to history; that is, the literBry trail of star jelly. They present only a few brief anécdotas. (R29)

X27. 1994. Oekville, Washington. The mysterious appearance of gelatinous material on the earth's surface persists in modern times. However, shooting stars are not usually seen beforehand. The terrestrial substance, though. is still usually presumed to have fallen from the sky.

A case in point is that of D. Hearn, the owner of a small farm near Oakville, Washington. Hearn saw nu falling star, but one day she did find a suspicious deposit of a jelly-like maternal. She testified:

"After a rain shower 1 stepped out onto my back porch and there was this white clear gelatin-like substance all over everything. .. It was in chunks about the size of grains of rice." (R30)

The widespread deposit of srnallish bita of jelly-like substance does not match the largar single blobs of classical star jelly. The presumed "fall" on Hearn's farm, though, was curious enough to earn an airing on Arthur C. Clarke's Mysterious Univorse TV pro- gram.

X28. General observations. Like the Oakville event (X27), gelatinous masses are still found in fields and marshes today, but none of their observers link them to shooting stars. A 2004 issue of New Scientist printed several letters on the subject of pwdre ser or star jelly.

Yesterday's natural philosophers and today's biologists have alwavs associated these actually rather common gelatinous lumps with female frogs Frogs are great favoritea uf herons, crows. raccoons, and other marsh predntors. The gelatinous masses are claimed by we modern ratíonal people to be only frog spawn regurgitated by frog-enters Falling stars are no longer pnrt of Míe eqnntion!

A problem rpmains, though. Today's gelatinous masses are almost alwoys devoid of frog eggs and are often much larger than the average female frog. These could be formidable scientific enigmas.

Happily, a reasonable explanation carne lo the mind of A. Grey:

"The predator swallows the frog be- fore ovulation. The predator regurgP" tales only the oviduct lining whinh swells enormously when in contad with water. Voila! A largish gelBtinous mass sans eggs."

Today, the pwdre-ser enigma seems to heve been rooted out of the modern mind. But can we really completely ignore the following oldlsh anecdote written in Scientific American (2:79, 1846)?

"...the most remarkable meteor ever seen in thst section ILoweville, NY] made its appearnnce from the west. It appeared larger than the sun, illumined the hemisphere nearly os light as day. It was in sight nearly five minutes and wos witnessed by a greot number of the inhabitante of the village, and finally fell in a field in the vicinity, and a large company of the citizens immediately repaired to the spot and found u body of fetid jelly, four feet in diameter."

Not only is the size of the Loweville star jelly remarkable, but so is the long iife of the "meteor"! It could not have been a normal shooting star ñor a frog's oviduct lining.

In 1846, anécdotas were often em- bellished.

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122, 1830. (X19-X22)

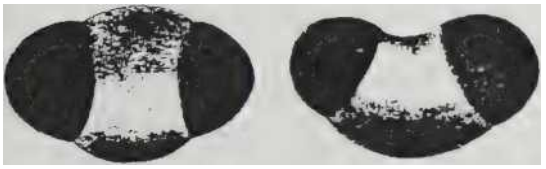
X19. June 18, 1860. Amesbury, Massachu- setts, and Prospect, Nevv York. After a thunderstorm, the ground was covered with "sulphur. " It burned with a blue fíame and smelled like common sulphur. The writer noted that such observations are usually due tn pine pollen. (R20)

X20. March 12, 1867. Sc.uth Union, Kentucky. A yellow substance falls with rain. (R21) X21. February 14, 1870. Genes, Franco. A remarkable yellow rain. Analysis yielded mostly sand, clay, iron oxide, and some organic debris. (R22) See also X7.

X22. April 25.. 1880, Bonneville, Switzer- land. A rain made yellow by vegetable de- bris, which included spores but no pollen. (R23)

X23. April 8, 1906. Central China. The air was filled with dust. A subsequent rain left puddles ringed with a yellow substance that the local doctor identified as sulphur. ÍR24)

X24. April 10, 1907. Sanary, France. A yellow substance fell with rain. Vvhen dried it resembled "flowers of sulphur," and was generally believed to be that form of puré sulphur. Application of » microscope, however, showed that it was only pine pollen. (R25)



The so-called "sulphur rains" g't theír yellow color ¡rom pollen grains such as ¡hese /rom pine irees. Diameters: 75 rnicrons. (X24)*

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GWF4 Falls of Miscelianeous Inorganic Substances

Description. The fall from a olear sky or with normaJ prectpitation of inorganic substances, su oh as crystalline material and cinders, but excluding sulphur-like substances (GWF3), stones (GWF2), dust, and ashes. The criteria employed in choosing examples here are:
(1) Unusual **Chemicals** not expected in precipítation; (2) .Materials that do not seero to exist in the immediate vicinity of the fall; and <3) Anomalous meteoric material. Goal is considered "inorganic" here.
Background. Dust and ash falls are common and generallv well-explained. They are omitted.

Data Evaluation. The data are rather convíncing and minus the sensationalism associaled witb sulphur falls and thunderstones. Rating: 2.

Anomaly Evaluation. Most of the substances mentioned here are common In nature. The anomaly consists primarily of finding reasonable sources and transporting mechanisms.
Since winds fit the bilí quite well, the only mystery remaining is locating nearby sources or explaining transportation over long distances. Rating: 3.
Possible Explanations. Salt storms are easíly attributed to the evaporatíon of wind-blown seawater. The other falls are líkely wind-blown debris or incoming meteoric particles.
Similar and Related Phenomena. AJI falle, especially stone falls (GWF2).

Examples of Falls of Miscelianeous Inor- gamc Substances

XI. Date of fall indetermlnate. Arctíc.
From the log of the Vega expedüion. "Líeu- tenant Nordquist observed srnall yellow specks in the snow, which I asked him to collect and hand over for investigation to Dr. Kjellman. For I supposed that the specks consisted of diaiom ooze. After ex- amining them Dr. Kiellman however de- clared that they did not consist uf any or- ganic substance, but of crystallized grains of sand. 1 too now examined them more closely, but unfortunately not untll the mor- ning after we had left the íce-field, and then found that the supposed ooze consisted of palé yellow crystals (not fragments of crystals) without mixture or foreign matter. The quantity of crystals, which were ob- taincd from about three litres of snow, skimmed from the surface of the snow on an area of at most 10 square metres, amounted to nearly 0. 2 gram. The crystals were found only near the surface of the snow, not in the deeper layers. They were up to 1 mm. in diameter,.... and ap- peared to belong to the rhombic system, as tbey had one perfect cleavage and formed striated prisms terminated at either end by truncated pyramids. Unfortunately, Icould not make any actual measurements of them, because after being kept for some time Ln the air they weathered to a white noncrystalline powder. Tliey lay, without being sensíbly díssolved, for a whole night tn the water formed by the melting of the snow. Ün being heaied, too, they fell asimder tato a taste- less w'hite powder. The white powder, that wa8 being formed by the weathering of the crystals, was analysed after our return--------- 21 months after the discovery of the crystals— and was found to contain only carbonate of lime." (RI) It is assumed that these crystals fell onto the Arctic snow. (WRC)

X2. 1916. Northern Ireland, "The great barometric depression that developed from the 16th to 18th with íts prolonged south- easterly blast, has brought a great shower of salt that 1 have traced as far inland as the Lough Neagh dlstrict. ít was first detected on I8th, dimming the Windows facing east- ward, but some of the more succulent and absorbent forms of vegetation have aleo re- vealed its preseoce by wilting under the poisonous blast." (R2) See alsoX3. Obvious- ly this phenomenon is caused by wind-blown seawater that is evaporated, leaviug salt be- hind. See also tile effects of the so-called "blasting fogs" (GWD3-X6).

X3. Circa 1815. Massachusetts. After a nigh wind and heavy rain, all homes and objects within a mile of tne water were coated with salt. *(R3)*

X4. August 20, 1872. Zurich, Switzerland. "Prof. Kenngott, of Zurich. staies that in a hailstorm, rm the 20th of last August, the st.tnes, some of which weighed twelve

gralns, c-onsísted essentially oí common salt. mainly in imperfect cubical crystals. He supposes that the salt had been takenup from the salt plains of Africa, and brought over the Medíterranean. " (R4)

X5. June 1893. Daduzai. India. "A few days ago ¡n a village named Daduzai (a tebsil ir. tlie Peshawar district) rain te 11, preceeded by a wind storm, and wíth the rain carne a shower <>f haüstones; which lasted a few minutes. The most curious part of this occurrence ifi that the hailstones when touched were not at all coid, and when put Ln the mouth (as is the custom in this hot country) tasted like sugar- 1 am further told that the hailstones were extremely fragüe, and as soon as they reached theground they broke mto pieces. These pieces when examíned looked like broken stlcks of cry- stallised nitre. My informant tasted Ihtrn, and was struck with their purity and sweet- ness. ” (R5)

XG. Marcn 2, 1940. Springfield, Missouri. "Immediately after the hail storm Mr. R. F. Buchanan of *808 S. Douglas Street in this city called the office and advised me that ít had ’hailed coal in his part of town' and that he was bringing some of the hail stones to my office. He arrived shortly but the hail had melted before he got here. He showed me his car which he had just fínished wash- ing prevlous to the storm. It was literally covered wlth small pieces of coal, varying from one sixteenth to one eigbth of an inch cube size. Eacb little piece of coal was encased in a small muddy circle on his car where the hail had melted. There were thousands of them on the car top and sur- face. He said that eaeh hail stone was black in the center before it melted. His lawn, sidewalk and the Street in his section of the city were covered witb the bits of 'coal' while several blocks away otbers advised me that they had noticed the same thingonly ít was mostly a black dust depositafter the rain. In all other sections of the city the deposit was a yellow dust." Author sur- mi sed that a small tornado mlgbt have car- ried the coal from strip mines a hundred miles away. (R6)

X7. November 14, 1856. South Pacific Ocean. Spherules of magnetic material the size of birdsbot fell on a ship. It was supposed that Lhis was meteoric dust. (R7)

X8. Circa 1885. Pelham, New Hampshire. Metallic dust and granules, identifleda6 meteoric dust, found on a sidewalk after a thundershuwer- (R8)

X9. November 14, 19G8. Jurmenha, Portugal. A rain of ’sand' accompanied the fall of the so-called Alandroal meteor. (R9)

X10. June 17, 1857. Ottawa, Illinois. "The cinders fell in a northeasterly direction ln the shape of the letter V. The weather had been showery, but I heard no thunder and saw no lightning, There appeared to be a small, dense black eloud hanging over the garden in a westerly direction, or a little to the south of weet. The cinders fell upon a sligbt angle witbin about three rods of where 1 was at work; there was no wind at the moment, or none perceptible. My at- teution was called first to the freak the wind had in the grass, the next moment to a his- s'ing nolse caused by the cinders passlng through the air. The larger ones were con- siderably imbedded in the earth, so much as only to show a small part of it, while the smaller ones were about half buxied. I noticed at the time that the ground where I af- terwards picked up the cinders showed signa of warmth, as there was quite a steam or fog at that particular point. " The cinders were glassy with a cellular interior. They were a little over an inch long. Color- black. (RIO, Rll) The "cinders" do not appear to be meteoric because of tneir cellular struc- ture, although ln 1857 there were probably lew sources of real cinders in this región. The black eloud, however, resembles those frequently seen in the vicinity of descending meteors.

Xll. Januery 31, 1686. Courland, Rus- sia (?). "A meteoric substanee like black paper is said to have fallen near Handen in Courland, on the 31sl January 1686. This fací led ¡Vi. Von Grothus to recognize it in a substanee ir. his own museum, which had a label attached to it. stating it to be of meteoric origin.
It is a mass of black leaves resembling burnt paper; but it is harder, brittle, and coheree together. It has been found to consist of silica, magnesia, iron, some nickel, and traces of chromium, the same ingredienta as those of meteoric stones." (R12)

Note that in 1686 the words "meteoric origin" mean! anythlng associated wíth weather. In those days, extraterrestrial objeets did not fall from the sky!

X12. January 6, 1909. Snnt8 Cruz, California. Mrs. W.H, Burns was alerted to a singular phenomenon by children play- ins? in front nf her house. They told hrr

tliat "hot shot" was falling from the sky.

"Then she heard the cíatter on the housetop like hail and saw little white threads of sleam rising from neighboring roofs. This steam was found to be the result of the dropping of little hot globules on the damp shingles.

"This peculiar rain continued from about 3 to 4 o'clock in the afternoon, and varied in intensity. At one time the children, who were bareheaded and un- shod, were compelled to take cover." (R13)

The purported "shot" referred to bird shot such as that used in shotgun shells. Apparently. none of these hot bits of metal were saved or examined by scien- tists. Something hot did fall, bm its nature and origin remain unknown.

X13. April 10, 1815 and some days thereafter. IVlount Tambora, Indonesia, and much of Southeast Asia were exposed to a m8sssive fall of volcanic ash. The amourd of ash falling in the first few days after the eruption was estimated to be 40-90 cubic kilometers. Some of the ash remained suspended in the atmo- sphere for months and heavily impacted the weather in the Northern Hemisphere. Temperatures were depressed and North America and Europe experienced in 1816 the íamous "yet<r without a summer."

The Tambora volcanic eruption was the largest volcanic event and ash fall since the last lee Age. (R14)

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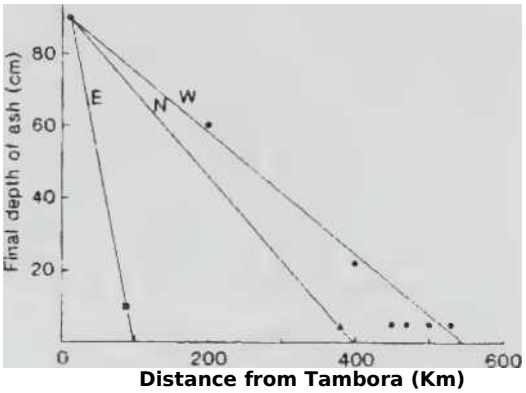

Estimated thickness *of Tamboro ash faU as a function of distance in the east, north. and* ***wesl*** *direclions. (X13)*

X14. March 11, 1984. Duncan, British Columbia, At 8:30 P.M., D. Thompson spotted a burníng object falling frorn the sky. It landed in the Street about 200 feet from him. He testified: "There was a fíame for about three seconds and then it went out . i kind of ran up to it and 1 could hear it eizzle." The sizzle was due to the wet pavement.

When the fíame had burnt out, a hard yellow, nearly circular mass, about l- inch thick remained. Thompson scraped up most of the substance along with bits of asphalí. The substance was odorless and soluble in water.

A aample was reportedly sent to the University of British Columbia. We have seen no results from eny analysis. {1116}

X15. June 5, 1983. Bournemouth, United Kingdom. A report of a fall of coke was sent to the Journal of Meteorology by P.A. Rogers, thp Meteorológica! Registrar for Bournemouth.

"After the severe thunderstorm of 5 June 1983, it was brought to my atten- tion that large amounts of coke had fallen in a gentleman's garden. After being reportad in the local press and on local radio that evening, my telephone never stopped ringing with reporta of coke having fallen all over the Bournemouth, Poole and Christehurch area. I investigated several reports and found the pieces to be the same, all having been discovered over lewns, paths, etc. and all found after the storm of the 5th.

At one lady's house 1 picked up 92 pieces of coke and there were still many pieces left. The largest piece of coke measured 6.0 by 4.6 cm. At one investi- gation 1 was given small roof-like clip- pings which the lady said she saw in melting hailstones." (R16)

Piles of coke are not uncommon in industrial areas. It would, however, require powerful winds to pick up such large pieces and distribute them over such a wide area.

X16. June 16. 1979. Mississauga, Cañada. On a hot. sunny afternoon in 1979, T. Hatchett and his daughter were working in their baekyard, when they heard a louri thump followed by n crarkling sound. A molten blob of "somelhing" about 4 inches high had landed on their picnic table. A column n| fíame was shooting upward from it. llHtrhett's daughter quickly doused the flames with a garden hose. The eooled, soJidified residuo was

D small. fíat, green ness weighing about 4 ounces.

The incident was reported to the Toronto Sun and stirred considerable interest. Quenes indicated that no corn- mereial ñor military aircraft overflew when the event occurred. A sample analy- sis by the Ontario Ministry of the En- vironment proved that the substance was the common plástic polypropylene. The source of the burning blob was never found. (R17)

Note that the Mississauga "blob" re sembles the curíous burning mBSS that fell on a Street in Duncan, British Columbia in 1984. (XI4)

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GWF5 The Fall of Marina

Description. The fall from the sky of large quantities of edible substance. Manna is gene- rally granular in forro and may appear in various colors, consistencíes, and flavors. Al- most all reported falls of manna come from Asia Minor.

Background. Discussion of the possible fall of manna is inescapablc due to its prominence ín Biblícal history and folklore.

Data Evaluatlon. The actual fall of manna from the skies is claimed only in a few oíd and questionable sourees. More sober observers tell of: (1) The collection or fall of edible sub- stances from trees and bushes; (2) The sudden appearance of edible plants and líchens due to natural populatlon explosions; and (3) WInd-blown líchens. In sum. the data supporting actual falls of manna from the skies is very shaky. Rating: 4.

Anomaly Evaluation. Even if manna did fall from the sky or arrived with normal precipitaron, it is light enough to be carried long distances by meteorological agencies. The large, locallzed falls, however, are curious. Rating: 3.

Possible Explanations. Two varieties of manna seem to exist: (1) Lichens, wind- blown and indigenous; and (2) Sugary granules produced by inseets and/or vegetation.

Similar and Related Phenomena. All other falls, particularly the rare prodigious falls of leavts and hay 'GWF6).

GWF5 FALL OF MANNA

Ex ampies of Falls oí Maana

XI. 1824. Persia. Ground covered in some regions by edible Ucbens, called manna. **(RI)**

X2. 1828. Persia. Edible substance saidto fall írom tbe sky. "It uccurred in such abun- dance that the ground was of a sudden entire- ly covered by it over a great extent. In some spots ít was five or six inches deep. It was caten by cattle, and particularly sheep; and bread was made of it, which afforded nour- ishment to man. Such were the accounts furnished to the French Cónsul in Persia, by a Russian general, who was an eye-witness." (RI) The fallen substance was later identi- fied as the plant Parmella esculenta. (R2, RIO) This classic example saíd to occur in 1829. (R3)

X3. Spring 1841. Lake Van, Turkey. The ground was covered to depths of 3 or 4 inches by a gray, granular substance that was pleasant to the taste. Bread was made írom it. (RIO)

X4. January 1846. Jenischehir, Turkey. Edible substance falls during a time of lamine. "It lasted some days, and the pieces of lichen were of the size of hazel-nuts.
Tbey were ground into flour, tbe bread from which was pronounced little inferior towheat bread. Anotber account says that the manna was of greyish-white colour, rather hard and irregular in form, inodorous and insi- pld. " |R10, R17j Another report puts Lhís fall in April lo4G. (R3)

X5. April 18, 1848. Byazid, Turkey. Edible lichens said to ha ve fallen from the skies. (R4)

X6. July 1864. Diarberker, Turkey. Manna appeared. Said to be lichen. (R5, R6)

X7. Circa 1887. Turkey. The followingdes- cription was provided by a Mr. Colé, an American missionary. "We travelled for four days through a región where had newly fallen a remarkable deposit of heavenly bread, as the natives sometimes cali It— manna. There were extensive forests of serubby oaks, and most of the deposit was on the leaves. Thousands of the poor peas- ants, men, vvomen, and children, were out upon the plains gathering the sweet substance. Some of them plunge into kettles of boiling water the newly cut branches of the oaks, which washes off the deposit until the water becomes so sweet as to remind the Yankee of a veritable sugaríng off Inthe oíd Granite State as he takes sips of it. Other companies of natives may be seen vigorously beating with sticks the branches, that, hav- iiig been spread on the ground, have so dried that the glistening crystals fall readily upon the carpet spread to roceive them. Tht cry- stals are separated from the pieces ofleaves by a sieve, and then the manna is pressed into cakes for use. " (R8)

X8. August 1890. Diarbekír(sic), Turkey. "The director of the central dispensary at Bagdad has sent to La Xature a specimen oí an edible substance which fell during an abundant shower in the neighbourhood of Merdin and Diarbekir (Turkey in Asia) in August 1890. The rain which accompanied the substance fell over a surface of about ten kilometres in cireumference. The in- habitants collected the 'manna, * and made it into bread, which is said to hav» been very good and to have been easil' Jigested. The specitnen sent to La Nature is composed of small spherules; yellowish on the outsíde, it ís white wíthin. Botanists who have ex- amined it say that it belongs to the family of lichens known as L ecanora esculenta. " (R9)

X9. General observations. Sinai, Egypl. An expedition from the Hebrew Univer- sity was sent out to determine the true nature of the Bíblica! manna. It found that twm scale inseets in the región excretad a clear, sweet fluid that cry- stallized into grains and fell to the ground from the trees. (R16)

X10. March 1900. Chanda, India. During a great famine, bamboo trees exuded a type of edible manna. (R13)

XI1. General observation. "Our Cónsul in - Jerusalem States that manna is found now in the regions of upper Mespotamia and Kur- distan and along the Persian frontier. It falls, he says, in the form of dew during September, October, and November, and lodges upon the leaves of oak trees. It im- mediately hardens and aseumes the form of a grain. Early in the moming before the heat of the da> ¡lis gathered by spreading sheets beneath the trees, which are shaken, and the manna is then collected and stored for winter to be used as a food or shipped to Bagdad for sale in the bazaar. The manna falls on other vegetation, including the grass but all of it is lost except that which is gathered from the oak leaves. The manna is sweet and is eaten by the natives as a substi- tute for sugar or hunev. " (R15) Such wide- spread occurrences would seem lo Indicate that the manna is not the product of a speci- fic tree. See X12 and X13.

X12. General observation, A kind oí marina is produced by the linden in Europe. (R7) X13. General observations and controversy. No agreement reached on wbether the marina uf the lsraelites was lichene or a product oí the tamarisk tree. (RIO, Rll. R12, R14)

X14. General observations. "An account oí manna 'rains' certainly pertains to the dis- cussion of showers oí vegetable niatter, for the substance manna consists of lichens of the genus Lecanora, but in none of the nu- merous reeorded instances of manna'rains[1] is there any direct evidence that the sub- stance really fell from the sky. These tic — hens form, small, round bodies that are easily blown over the surface of the ground and accumulate in depressions; they are very buoyant also and henee easily drifted into masses during the run-nff of rain water. Manna 'rains' have not oceurred except in euuntries where these lichens are common. and as for statements of their falling down upen roofs or upon people, or for any other proofs thaL they really rained duwn. I have seen none." (R18)

Xl5. General. North Africa, Middle East, Southwest Asia. The edibilíty of lichens and the many tales of manna were 8d- dressed briefly in a 1971 technical book by J.H. Bland dedicated to mosses ar.d lichens in general. Bland wrote:

"The Manna Lichen (Lecanora excu- lenla), a desert species~of Crusty Lichen, probably fed the lsraelites in their piight in the desert. It is still eaten by desert tribes, who mix lt with mea! to one-third of its weight and make it into bread. In Southwest Asia, it is used as a substitute for corn." (R20) Windstorros can sweep up loosely attached lichens and deposit thein else- where to provide one basis of "falls of manna."

”In recent times a remarkable deposit of lichens oceurred in Mesopotamia during a sudden hailstorm. When the hail melted, the ground was covered with lichens; speciemens were sent to a scientist named Errera who identified them as Lecanora culenua- His opinión was that two kinds of manna are re- ferred to in the Bible; in one case (Exo- dus XVI:4) it is the sweet gurn of the tamarisk, í> graceful evergreen shrub or smnll tree, with slender, feathory branches in Southern Europe and western Asia; th«' other kind (Numbers XI:7-9) plainly refers to the lichen.” (R20)

X16. August 1980. Hawley, Pennsyl- vania. On an early summer pvening, p~.W7 Becker. a census taker, was sil- ting in his car **Consulting** a map. The car was parked on a dend-end Street No people or other cars were in sight.
Becker reported:

"Suddenly there was a horrifio bang Hnd the car rocked. A missile from the the sky lay in plain view, square in the center of my car’s hood.

"1 eautiously got out to examine the fallen object. Tiny pieces had broken off, but it was largely intact and mea- sured four to five inches across. I smelled it—-yes, it still carried a faínt scent—of pizza! lt was a slice of pizza, solid as n rock and stone coid. This was no ordinary meteorito. 1 thought of God feeding the lsraelites manna from he8ven, but God knows 1 prefer pepperoni. This was plain, tornátil and cheese. on a thin crust. (R21)

Who said Science does not have íts humor?

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GWF6 Unusual Falls of Hay and Leaves

Description. The fall from a olear sky or with normal precipitation of large quantities of hay or dead leaves. Many of these falls begin at great heights and may continué for hours. The sources of these malerials may be miles from the place-of-fall. A curious feature of this type of fall ts the apparent lack of debris among the hay or leaves and, in the latter case, the presence of only one type of leaf.

Background. Virtually every country lad has seen cut hay suddenly whipped aloft by whirl- winds and deposited on rooís and telephone wires. The falls meriting mention here are notable for the heights involved, great quantities of materials, long distance of travel, and long duration ot fall.

Data Evaluation. This phenomenon is well-documented in the older literalure. Rating: 1.
Anomaly Evaluation. This phenomenon, as defined above, is merely an extreme case of well-known pranks of whírlwinds. The only possible mystery is the high selectivity of the transporting agency; i.e., the lack of debris and more than one species of leaf. Rating: 3.

Possible Explanation. Whírlwinds and tornados.
Similar and Related Phenomena. Other falls in the GWF section, especially GWF10 and GV/F11 where the falls are usually devoid of other animal species and also the natural debris (plant matter, etc.) that one would expect from an animaFs habitat.

Examples of Unusual Falls of Hay and Leaves

XI. Clrca 1845. England. Quoting a letter from Str John F. W. llerschel. "In the hay season, some three or four years ago, the day being clear and hot and calm (at least in the immediate neighbourhood of our house), our attentíon was excited by wbat first seemed to be strange-looking birds flying; but though presently assured they were not birds, it was by no means clear what they were, They we-re irregular wispy maesea sailing leisurely up and settling down agaln, apparently over a hay field on the east of our grounds, and about a quar- ter or three-eighths of a mlle from our house. Some of these were of considerable size, and their general appearance was convex downwards and taily upwards. After wondering awhile, I got a telescope and di- rected it to the flying phaenomenon when it became evident that they were masses of

----some of very considerable size, eer- tainly not less (allowing for the distance) than a yard or lwo in diameter. They sailed above leisurely . and were very nu- merous. No doubt wtnd prevailed at the spot, but there way no ruaríng noise, ñor any sign of a whirlwlnd, and all about us was quite calm." (RI)

X2. September 1861. Putney, England.

Clumps of hay fell from great heights. (R2)

X3. July 27, 1875. Monkstown, Ireland. "About half-past nine o'clock this moming, as 1 was standing at a window facing east, in Monkstown, my attention w as called by the Rev. T. Power to a number of dark floeeulent bodíes ñoating slowly down through the alr from a great helght, appear- Lng as if falling from a very heavy, dark cloud, which hung over the house. ün go- Lng to the hall door, a vast number of these bodíes were discerned falling on all sides, near and far, lo as great a distanee as
theír size permitted them to be seen--------
over an area whose radius was probably between a quarter and half a mile. Pre- sently, severa! oí these flocks fell cióse to my feet. On picking up une, it was found to be a small portion of new hay, of which 1 endose a sample. When it fell it was as wet as Lf a very heavy dew had been de- posited on it. The duration of this phenom- enon, from the time my attention wasñrst called to it till it had entirely ceased, was about five minutes, but how long it may have been proceeding before this I cannot tell. The flocks of hay, from their loose, open structure, made a large appearance for their weight, but the average weight oí the larger flocks was probably not morethan one or two ounces, and, from that, allsizes were perceptible down to a single blade. There was no rain from the dark cloud over- head, though it had a partícularly threatening appearance at the moment of observatíon.
The alr was very calm, with a gentle under- current from S. E. The clouds were moving ín an unner-current from S, S. W," (R3, R4, R5, RIO. R12, R17)

X4. June 17, 18S4. England. During fine weather, considerable hay passed over- head. Some fell, but some armful-sized bimches saíled along until out of síght. (R6)

X5. July 26, 1891. Boraston, England. ”We had a curious sight from this house yester- day. Lt was a dead calm, but in a field just below the garden, with only one hedge between us and it, the hay was whirled up high lnto the sky, a column connectlng above and below, and in the course of the evening we found great patche3 of hay raining down all over the surrounding meadows and our garden. It kept falling quite four hours after the affair. There was not a breath of air stirring as far as we could see, except in that one spot- ” (R7)

X6. June 30, 1807. Belchamp St. Paul, Eng land. A whirlwind carric-s hay out of sight at Halstead. !t falls (apparently) at Belchamp St. Paul, 3 miles distant. Some of it was in large bunches. (R8)

X7. June 7, 1906. Sprimont, France. A cloud of hay obscures the sun, (R9)

X8. July 31, 1920. Stone, England, Wisps of wet hav, larger than dinner piales, fnll. (Rll, R19)

X9. June 28, 1931. Spa, France. (R13)

X10. October 1889. Dumfriesshire, England. ”1 was struck by a strange appearance in the aímosphere, which I at first mistook for a flock of birds, but as I saw them falling to the earth my curiosity quickened. Fixing my eyes on one of the larger of them, and running about 100 yards up the hill until di- rectly underneatb, 1 awaited its arrival, when I found lt to be an oak leal. Looking upwards the air was thick with them, and as they descended in an almost vertical direc- tion, oscillating, and glittering in the sun- shine, the speetacle was as beautiful as rare. The wind was from the north, blow*- ing a very gentle breeze, and there were oc- caslonal showers of rain. On examination of the hills after the leaves had fallen, it was found that they covered a iract of about a mile wide and two miles long. The leaves were wholly those of the oak. No oak trees grow in clumps together nearer than eight miles.” (R14) Same incident placed in 1890. (RIO)

Xll, Apríl 7, 1894. Clairvaux, France. lt rained dead leaves for half an hour. **(R15)**

X12. April 1, 1900. Wallingford, England. "At about four o'clock on the aftemoon of Sunday last (April lst), my attention was arrested by the fall of numbers of dried beech leaves. Ün looking up I found that the leaves were passíng Ln large numbers from east to west, and as high as the limit of Vision. Many appeared to be mere speeks, whose height and motion promised them a journey of some miles at least. The shower continued for perhaps twenty minutes. The fall was noticed by many persons here, who were unable to account for it, as there are no beech trees within two miles at nearest. Probably the leaves had been raised by a whirlwind, and at a very considerable dis- tance east of this neighborhood." (Rlfi)

X13. August 17, 1883. Aarao, Switzer- lBnd. On » windless day, clouds alter- nating with sun, a delnge of bay rained down on this Swiss towri. The stalks

eovered roofs, trees, roads, and gar- dens. The clumps fell slowly, like snow. A seemingly infinite number of long stalks could be seen at great heights among the elouds, which were drifting north. The high-altitude flight of hay persisted for 3 hours. (H18)

X14. April 19, Blois, France. The wind at the surface was ealm when leaves bogan raíning down in quantity from a slow-moving cloud hundreds of rneters above. The leaf fall lasted for 6 hours. (R19)

X15. July 28, 1992. Essex, England. "The mystery downpour started after lunch yesterday, with evewitnesses claiming to hBve seen large lumps of straw falling from hundreds of feet up.

"No rational explan8tion could be offered by sceptica! Met Office spokes- man Barry Park.

"Mr. Ü8vid Jenkins of C.ommonhall Laño said: 'There were large handfuls of straw, líke you would put in a rab- bit hutch, falling out of the sky.'

"Mr. Jenkins, who is retirpd, added: 'There were hundreds and hundreds of them, they must have been whipped up by the wind or something.'"

Mr. Paul Moore of Hall Crescent claimed to have seen hundreds or lumps from the size of a quarter bale falling from 1 ,ttlíO feet up, looking as if they hed dropped from a cargo plañe, and clumps of straw were in the trees of nearby John Burrows recreation ground where they tended.

A baffled Mr. Perk at the London Meteorlogical Office said although tor- nadoes or even dust devils could pick up straw, weather condítions were un- suitable and could not lift up the amounl described to such great heights, (R20)

Once again, it is the total quantity of straw, the large lumps, the great heights involved, and the slow rates of descent that impress the anomalist.

X16. July 1994. Wooburn Creen, United Kingdom. In mid-July, about 10 tons of hay fell on Wooburn Creen. Some lumps were as large as bales. They seemed to float down gently. like balloor.s, lo the ground. A large area surrounding the town was eovered. (R2n

X17. July 22, 1997. South Molton, United Kingdom. About 3:30 P.M., F. Holcombe was sitting in his garden "when a Isrge clump of hay about the size of a footbail landed next to him. He was bewildered as to where it had come frorn and looked up into the sky and saw that it was full of hay oí different size lumps as far up as the elouds." There was no wind at the surface. (R22)

X18. August 1999. Lincolnton, North Carolina. Leaves from corn stelks up a yard long fell frum great heights in many parts of Lincolnton. The weather was fair. WInds were light. No thunderstorms were in the area. (R23)

How did the corn leaves become de- tached from their stalks? Usually, stalks and leaves are ground up together for ensilage.

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GWF7 Gelatinous Meteors or Pwdre Ser

Description. The fall cf gelatinous masses, usually accompanied by luminous phenomena. The substance is soft and jelly-like, odiferous, and has a tendency to evapórate away rapidly. Gelatinous meteors range from a few inches to four feet in diameter according to reporta.
Background. The idea that offensive masses of jelly-like substance can fall from the sky is fírmly entrenched in folklore, as confirmed by many colorful ñames, such as pudre ser (a Welsh term, more correctly spelled pwdr ser), star shot, rot of tile stars, etc. In the ex- amples that follow, the reader will find two different phenomena confused: (1) The observed fall of something from the heavens; and (2) The discovery Ln fields of gelatinous masses.
The lalter phenomenon possesses a simple biológica! explanatíon----------assuming tbe mass did not fall. The actual fall of jelly-like substances admits to no easy solution, assuming its reality.

Data Evaiuatíon. With few exceptions, the observations of gelatinous meteors in flight are oíd and rather shaky. Many examples profferred as cases of gelatinous meteors are weak- ened by the strong possibilíty of misidentification and coincidence; that is, one sees a luminous body descend nearby, searches the next morning, discovers a gelatinous mass in the general direction of the visual phenomenon, and calis it a gelatinous meteor. Meteor im- pact points are easily mlsjudged, and natural gelatinous masses seem rather common in fields. Nevertheless, many cases cannot be elíminated easily, and there is much internal consistency. Rating: 3.
Anomaly Evaluation. The confirmed descent of gelatinous masses from outer space would constitute a significant anomaly, for (quite obviously) they do not fall into any recognized class of meteorites. Rating: 2.

Possible Explanations. Most of the so-called gelatinous "meteors" are most likely iust terrestrial substances, such as plasmoriia, decaying fungí, water swollen and distorted animal reroains, and even man-made materials. True gelatinous meteors/ meteorites, if they <>xist, have no easy explsnntion.

Similar and Related Phenomena. Animal falls (GWF10-14). signs of extraterrestrial life in meteorites (panspertnia theory).

Examples of Gelatínous Meteors

Xl. October 21, 1638. Dartmoor, England. A thunderstorm of great extent and fury. A church was struck and wrecked by ligbt- ning. A loatbsome odor accompanied the phenomenon. "It seems that some person vvho ventured to go up into the wrecked tow- er, there dlscovered ’a round patch as broad as a bushel, which looked thick, sfi- my, and black, to which he put his hand, and found it soft, and bringing some from the wall, carne down and showed thatstrange compound. It was like a slimy powder, tem- pered with water; he smelling thereto, it was odíous beyoDd expression, and in a far higher degree of loathsomeness than the scent which was in the church when they first smelt it, being of the same kind, 'and the discoverer was shortly after attacked with severe colic. " (R20)

X2. March 24, 1718. Isle of Lethy, India. Gelatínous matter fell aJong with a ball offire. (R3. R5)

X3. March 8, 1796. Lusatia , Europe. A viscous matter fell with a meteor. It had the color and odor of varnish. (R3, R5)

X4. January 21, 1803. Silesia, Germany. A meteor feli with a whizzing sound and seemed to he burning on ground. Qn the next day a jelly-like mass w'as found on the snow.

X5. August 13, 1819. Amherst, Massachu- setts. "On the 13th of August, 1819, be- tween eigbt and nine o'clock in the evening, a fireball, of the size of a large blown blad- der, and of a brilliant white light, was seen in the almosphere. It fell near a house, and was examinad by Rufus Graves, esq. former lecturer of chemistry at Dartmouth College. It was of a circular form, resembling a solid dish, bottom upwards, about eight incbes in diameter, and about one in thickness, of a bright buff colour, with a fine nap upon it, similar to that of milled cloth. On removing this nap, a buff-coloured pulpy substance.of the consistence of soft soap, appeared, bav- ing an offensive suffocating smell, producing nausea and giddLness. After a few minutes exposure to the air, the buff-colour was cbanged to a livid eolour, resembling venous blood. It attracted moisture readily from the air." (Kl, R2, R13, R31) Probably the observers just thought they saw the meteor land where the jelly was found, and that they actually found only a Ierrestrially-produced plasmodium. (R19)

X6. November 13, 1833. Rahway, New Jersey. During the incredible meteor shower seen over much of the eastera United States. People saw a fiery rain and upon examination discovered lumps of jelly. (R6)

X7. November 13, 1833. Newark, New Jersey. A mass of gelatínous matter, like soft soap, was found after the great meteor shower. Forcé of impact disturbed the ground. Substanee evaporated readily when heat was applied. <R6)

X8. November 13, 1833. West Point. New York. Woman sees a round, flattened mass, the size of a coffeecup, fall. It vi'as transparent and quickly evapórate».!. (R6)

X9. 1830s. Lincoln England. Man sees a meteor fall in a field, found nothing but a lump of jelly. (R14)

X10. October 8, 1844. Coblentz, Germany. , a Germán gentleman ia friend of Mr. Greg's), accompanied by another person, late ín the evening, walking in a dry ploughed field, saw a luminous body descend straight down cióse to them tnot 20 yards off), and heard it distinctly strlke the ground with a noise; they marked the spot, and returning early the next morning as nearly as possible where It seemed to fall, they found a gelati- nous mass of a greyish colour so visrid as 'to tremble all over' when poked with a stiek. It had no appearance of being organic." (R&)

Xll. November 11, 1846. Loweville, New York. "...the most rcmarkable meteorever seen ín that section made íts appearance from the west, It appeared larger than the sun, illumined the hemisphere nearly as light as day. It was in sight nearly five minutes and was witnessed by a great num- ber of the inhabltants of the village, and fin- alíy fell in a field in the vicinity, and alarge company of the citizens immediately repair- ed to the spot and found a body of fetid jelly, four feet in diameter. " (R7)

X12. 1914. Ruesia. A brilliant eigar-shaped object crossed the sky. An unpleasant jelly-like substanee fell near the house of a peasant. It evaporated ín several hours. ÍR22) (Attributed to Znannya ta Pratza, no. 1, 1967.)

X13. February 3, 1980. Hemel Hempstead, England. 'Mr. Philip Buller found lumps of a colourless gel lying cióse together on his lawD. The lumps lay so near to one another that their common origín was not in doubt.
The total voluine was consídered lo be ap-

proximately sufficient to fill a yogurt cartón, say 75 mi.” A sample submitted for analysis was thought to be of amphibian origin and perhaps regurgttated by some preda- tor. (R26)

X14. No date given. Wales. A mass of jelly fell on a man working in a field. Nostorm or luminous phenomena reported. (R13) X15. No date given. Lowell, Massachusetts.

A man sees a brilliant shooting star fall to earth near him, Upon Lnvestigation he found a jelly-like mass with an offensive smell. (R16)

X16. Table of "doubtíul” meteorites. Falls of vlscid matter with luminous meteors reported in the years 850, 1110, 1548, 1557, 1652, 1686, 1718, 1796, 1811, 1819, 1844. (Since no details are given, and the observations are said to be questionable, no sepárate entries are provided. WRC) <R8)

X17. General observations. The analysis of substances found in a field and thoughí to be gelatinous meteors were found to be of animal origin and similar to snail jelly. (R4) The source of pwdre ser observations is probably the Tremella Nostoc, a jelly-like substance seen in wet places. (RIO)Jelly-like masses, callad 'pwdre ser* in Welsh, are fre- quently mentioned In literature and often associated with luminous phenomena. (R12) The jelly-like masses found in the fields are undoubtedlv plasmodia of a myxocete. (R15, R18~)

X18. General observations. Gelatinous masses found in fields may be food dis- gorged by herons. Such matter maj’ sometimes be luminous. (R18) These masses are probably the viscera of toads and frogs that have become swol- len with moisture. Herons may disgorge such matter and other predators maydis- embowel frogs and toads before consum- ing them. |R21)

X19. 860. Balch. Germany. (R27) See dis- cussion under X22.

X20. 1406. Lúceme, Swítzerland. See dis- cussion under X22. (R27)

X21. 1548. Mannsfeld, Germany. (R27)See discussion under X22.

X22 1557. Schlage, Germany. "These cases were firsl observed some time after they were belteved to have fallen from the atmosphere upon the earth; and it henee re- mains doubtful whether they were everlnthe atmosphere. Meteoric stones, índeed, sug- gest indications of atmospherical for marión, but these gelatinous masses poínt out no in- dications of the kind. Indeed botanista them- selves are at variance with philosophers about the matter of shot-stars, which is commonly colourless, and the Tremella meteorica, which Meycn recently described as Actinomyce, may be readily taken for a shot-star, if both are generally capable of being discriminated. it may be conceived that this is not necessary, and that the meteoric mass might assume the organíc and vegetable structure. To this it may be ob- jected, that the specimens of Tremella meteorica, are frequently found of different sizes, without it being probable that they are remains of a shot-star, especially where they are small, and, as ¡s commonly the case, occur attached to animal bodies, and even incorporated with them. It is there- fore improbable that it is sometimes formed terrestrially and sometimes meteorically, because the body exhibits too little charac- teristic peculiarity to owe its origin to cir- cumstances so very dissimilar. Resides, this supposes that the sudden origin of or- ganic bodies from unorganized materíals may be proved. As to the two cases of Lúceme and Mannsfeld, it is to be remem- bered, that, in the latter case, the blood- spots found un the soil, on the moming after the appearance and explosión of a fire-ball, admit of a verj simple explanation, that, in searching Tor something extraordinary, as the sign of a mass that had fallen, another fungus was found, the Telephora sanguínea, which Agardh cafls Pal mella cruenta; and which, on account of its entirely superficial extensión on moist ground, and frum its strikíng colour, exhibited completely the appearance of spots of blood I'he thick gelaninous masses of both the other cases is distinguísbed from the usual matter of shot- stars, the Tremella meteorica, by their red colour. It would therefore be of importance to examine whether similar ap- pearances are any thing else than this, with a particular difference of colour; whether they are definítely marked by a peculiar structure; or whether, in the absence ofany structure, ít can be pereeived to be an in- organic meteoric concrement, —a matter
hitherto undecided.” (R27)

X23. June 23, 1978. Cambridge, England. "1 wonder if you could tell me whal the sub- stance was that alighted on my lawn during a very beavy rainstorm last Friday evening (23 June). It glided down about the sue of a football and settled like a jelly . It was white and gloy- llke, but cellular. It didnot appear to disintegrate, but han completely disappeared by the morning l carne down

north-south. " This observation was subse- quently coiifirmed in writing by a neighbor. (R23)

X24. August 11, 1979, Frisco, Texas. "Two por pie blobs that Sibyl Christian found on her front lawn have defied analysis by space sei- entists, who say they haven't ruled out the possibility they could be a rare form of me- teorite. 'It's kind *oí* like a plum pudding,' aecording to Doug Blanchard, a geochemist at the National Aeronáutica and Space Ad- ministration near ÍLouston. Tt has round, solld chunks in it that remain after the goo goes away. We don't know what it is,' he said yesterday. [M] ÍR24) "The mysterious purple blobs found in a yard in this North Texas Lown and turned over to the nation's top space scientists for study are the Chemical leftovers of a baítery reprocessing plant, a Texas museum official says. And officials at the National Aeronautics and Space Admin- ístration say it looks like the museum official ís right. " (R25)

X25. Poetic references. Somehow, poets of the last few centuries could not re- sist inserting star jelly (or pwdrc ser) into their lines, From the many examples, we quote just two.

From Cowley:

"So stars appear to drop to us from sky,
And gild the passage as they fly;
But when they f«11, and meet th[1] opposing ground,
What but a sordid slime is found."

From Suckling:

As he, whose quicker eye doth trace
A false star shot to a market place Doth run apace,
And thinking it to catch,
A jelly up does snatch.

The point here is that the association of shooting stars with terrestrial lumps of jelly-like substances was deeply en- grained in the human mind not too long ago. This fact is emphasized again in the next entry ((X26). Of course, the poems and folklore only hint at a causa] eon- nection between a falling star and s jelly; they cannot prove the reality of this ancient claimed phenomenon.

X26. Folklore references. Star jelly, in all its many ñames, has pervaded the folklore of Europa over the ages. A 198 4 review of belief in this scientiíieally unlikely phenomenon, by H. Belcher and E. Swale. concludes with 102 references. The range of their literature '-enrch was irnmense. The reasoj) for the ubiquity and longevity of belief in star jelly ís probably due to the larga number of apparent coincidences on record of ob- servations of shooting stars followed by immediate discoveries of jelly-like mBsses nearby.

Belcher and Swale devote most of their article to history; that is, the literery trail of star jelly. They present only a few brief anecriotes. (R29)

X27. 1994. Oakville, Washington, The mysterious appearance of gelatinous material on the earth's surface persists in modern times. However, shooting stars are not usually seen beforehand. The terrestrial substance, though, is still usually presumed to llave fallen from the sky.

A case in point is that of D. Hearn, the owner of a small farm near Oakville, Washington. Hearn saw no falling star, but one doy she díd find a suspicious deposit of a jelly-like material. She testified:

"After a rain shower 1 stepped out onto my back porch and there was this white clear gelatin-like substance all over everything... It was in chunks about the síze of grains of rice." (R30)

The widespread deposit of smallish bits of jelly-like substance does not match the larger single blobs of clBssical star jelly. The presumed "faLl" on Hearn's farm, though, was curious enough to earn an airing on Arthur C. Clarke's Mysterious Dniverse TV pro gram.

X28. General observations. Like the Oakville event (X27), gelatinous masses are still found in fields and marshes today, but none of their observers link them to shooting stars. A 2004 issue of New Scientist printed several letters on the subject of pwdre ser or star jelly.

Yesterday's natural philosophers and today's biologists have always associated these actually rather common gelatinous lumps with feroale frogs. Frogs are great favorites of herons, crows. raccoons, and other marsh predators. The gelatin- ous masses are claimed by we modern rational people to be only frog spawn regurgitnted by frog-enters Falling stars are no longer part of the equation'

A problem remains, though. Today'5 gelatinous masses are almost always devoid of frog eggs and are often much larger tlian the average íemale frog. These could be formidable scientific enigmas.

Happily, o reasonable explanation carne to the mind of A. Grey:

"The predator swallows the frog befare ovulation. The predator regurgi- tRtes only the cviduot lining which swells enormously when in contact with water. Voila! A Iargish gelBtínous m8ss sans eggs."

Today, the pwdre-ser enigma seems to have been rooted out of the modern mind. But can we really completely ignore the following oldlsh anecdote written in Scientific American (2:79, 1846)?

"...the most remarkable meteor ever seen in that section {Loweville, NYJ made ita appearance from the west. It appeared larger than the sun, illumined the hemisphere nearly os light as day It was in sight nearly five minutes and was witnessed by a great number of the inhobitants <*t' the village. and finally fell in a field in the vicinity, and a large company of the citizens immediately repaired to the spot and found a body of fetid jelly, four feet in diameter."

Not only ís the size of the Loweville star jelly remarkable, but so is the long Life of the "rneteor"! It could not have been a normal sbooting star ñor a frog's oviduet lining.

In 1846, anecdotes were often em- bellished.

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GWF8 Prodigious Falls of Web Like Material

Description. The fall from great heights of large quantities of cobweb-like material in long strands, tangled sheels, and balls. Hundreds oí square miles may be covered as if by snow by fallen gossamer. Strands thousands of feet long have been reported. Some observers say the- strands are tough, hard-to-break, and sometimes seern to evapórate away. Web falls oecur mainly in the fall. Rarely are spiders reported attacbed to the webs.

Background. Gossamer falls are nothing new; bul the association of UFO stghtings with the fall of 'ángel hair' is a modern development.

Data Evaluation. Urdinary gossamer falls are rather common, but the observation of 1000- foot strands, ephemeral material, toughness of strands, and falls of immense areal extent are curious and raro. The rating applies only to such falls. Rating: 3.

Anomaly Evaluation. If all falls of web-like material can be attributed to spiders, no anoma- ly exists. The immense falls would simply follow from population explosions of spiders. If, however, the strands are not of animal origin, a serious anomaly emerges. Rating: 2,

Possible Explanations. The great majority of falls of web-like material can probably be. blamed on ballooning spiders. Reports of unusual web properties may be erroneous, although they are inte mal ly eonsistent. Mats and very long strands of cobweb may be due to the dumping and sticking of snialler webs.

The occasional modern association of gossamer falls with UFOs could be due to the sun’s reflection off high-altitude, shiny sheets of silken gossamer.

Similar and Reiated Phenomena. Some gelatinous "meteors" also seem to evapórate away (GWF7); ant-popuiation explosions (BAD in another volume); and the other falls in this section.

Examples of Prodigious Falls of Web-Like Material

XI. September 21. 1741. Selbourne, England. ”Thunder, ebb and fiood, and mist, are cow pretty well understood, and even the mystery of gossamer is no longer refer- red to the superstitious irnaginations of our forefathers. Yet the whole cause is not wist. We wot not how the spiders cast off their holdfasts and scud away, ñor how they adjust themselves for flight, and regúlate their movements; we only know that theydo it. No one Jcnows at present why, on par- ticular days» flakes oí gossamer shouldfall so fast upon the trees and hedges, that a diligent collector might gather basketfuls. Gilbert \Vhite, being ou a v isit to a friend and intent on field- sports, rose before day- break on the morning of the 21st September. 1741, and, on Corning into the enelosures, found the stubbles and clover- grounds mat- ted all over wíth a thick coat of cobweb, in the meshes thereof a copious and heavy dew, so plentiful that the whole face of the eountry seemed as ít were covered wíth two orthree settinE-nets drawn one over the other. When the dogs attempted to hunt, Ihey, blinded and hoodwlnked, were obliged to lie down and scrape the cobwebs from their faces with their fore-feet. As the morning ad- vanced, the day became brigbt, calm.ctoud- less, warrn, one of the loveliest oí autumn days, until about nine o’clock. when a sho- wer of cobwebs began to fail from the skies, which continued without interruption until the cióse of the day. These cobwebs were not single tbreads, but flakes or rags, which, as they fe 11, twinkled as they turned their sides to the sun. They were about an inch hroad by five or si.x long, and considerably heavier than tlie air, as they fell with some velocity. This shower was of a surprising extent, reaching Bradley, Selbourne, and Airesford, three places lylng in a sort of triangle, the shortest side being about eight miles in length. At Selbourne, a gen- tleman, thinkmg he could get above the shower, rodé three hundred feet above bis fields to the highest point he could reach; but the cobwebs seemed still as much above him as before, still descending into sight successively, and always twinkling ín the sun.” (R3, RG)

X2. October 1, 1S20. Wigan, England. The countryside was covered by a substance that was taken for.cotton. It carne down liko a sheet on Wigan. It containcd flies so small that a magnifying glass was re- quircd to make them perceptible. (R7> Attributed to the London Times oí Ooto- ber 9, 1820. **See** GWF8-X3 for a time- correlated fall in Brazü.

XS. Early October 1820. Pernambucu, Bra- zü. .. at the beginning of the preeeding month the re was a shower from the sky, consisting oí a substance resembling silk, of which many persons preserved specimens. This phenomenon extended to the distance of 30 leagues inland, and nearly as many off to sea. A Freneh vessel was covered with the silky material." (RI) See GWF8-X2 for a time-correlated fall ín England.

X4. October 1881. Milwaukee, Wisconsin. ”In the latter part of October the goodpeople of Milwaukee (Wis.) and the neighboring towns were astonished by a general fall of spider webs. The webs seemed to come from a great height. The strands were from two feet to several rods in length. At Grcen Bay the fall was the same, coniing from the di- rection of the bay, only the webs vnriedfrom sixty feet ín length to mere specks, and were seen as far up in the air as the power of the eye could reach. At Vesburg and Fort How- ard, Sheboygan, and Ozaukee, the fall was similarly obscrved, in some places being so thick as to annoy the *eye.* In ali instances the webs were strong in texture aDd very white. Curiously there is no mention, in any of the reports we have seen, of the pre- sence of spiders in this general shower of webs." (R4)

X5, September 20, 1892. Southeastern United States. "The postmaster of Gainesville, Florida, writet as folJows: T endose you something which has erealed a great deal of curiosíty in our community; it was first dis- covered late this afternoon floating in the air or falling from the clouds. I have seen people, who live at least ten miles apart,
who tell the same story------that it sometimes falls in long strands like spider webs, two and three tbousand yards long, then doubled up into strands and wads.' The following let- ter, written by a corresponden! from Gainesville, Fia., lo our fellow-member Judge L.
C. Johnson, or Meridian, Miss., refers to the same phenomenon; this letter is dated September 21, 1892; 'Of all the curious things ín nature the inclosed webs are a- mong the strangest. Yesterday great white sheets were seen floating with the daily showers, resembling large, puré white spider-webs, some of them fifty yards or more in length. The trees ín many cases are covered. Near the small strerun, about 100 yards from the house, some of it extended as an ímmense web; in other places

it rolled up into a ball. ’"{R5)

X6. Septembcr 26, 1948. Port Hope, Ontario, Cañada. "’This day was warm and the sky cloudless. We had had dinner in the garden and I was lying on my back on the lawn, my head just in the shade of the house, when I was startled to see an ob- ject resembling a star moving rapidly a- ci’oss the sky. The time was 2 o'clock, Eastern Standard Time. At first it was easy to imagine thai recent reporte uf 'Flying Sauctrs' had not been exaggerated. More of these objects carne sailing into view over the ridge of the house, onlv to disappear when nearly overhead. VVith field glasses I was able tu see that each was approximately spherical, the center being rather brighter than the edges. The glasses also showed quite a number at such heights that they were invisible to the naked eye. With only a gull flying in the sky for comparison, I should estímate the elevation of the lower objects te be about 300 ft. and the higher ones 2, 000 ft.; the size was about one foot in di ameter and the speed about 3ü m.p.h., in a directíon SW. to N£. Also visible now and then were long threads, ap- parently from spiders. Some of these were seen to reflect the light over a iength of three or four yards, but any one piece may of course been longer. Each was more or k-ss horizontal, moving at right angles to its length. in one case an elongated tangled mass of these gave the appearance of a fray- ed silken cord. These threads appeared only in the lower levels. " (R8j

X7. October 11, 1950. Butte County. California. The sky was filled with hundreds of silvery v.hite balls speeding north.
They seemed to divide, unite, and disap- pear. Size: about that of a dinner píate. The next day a mass of gossamer tras found caught in a tree. (B9)

XS. October 10, 1962. Montreal, Quebec, Cañada. "At 2000GMT while the Roxburgh Castle was moored to her berth (Section 24) in Montreal, J was walkíng around outside my accommodation and noticed fine white filaments of unknown kind hanging aroimd stanchions and topping lift wíres of derricks. Calling the attention of the Chief Officer, I pulled one of these otrands from a stanchion and found it to be quite tough and resilient. I stretched it but it would not break easilv (as, for instance, a cobweb would havedone) and after keeping it ín my hand for 3 or 4 minutes it disappeared completely; in other words it just vanished into nothing. Looking up we could see simal] cocoons of the material floating down from the sky but as far as we could ascertain there was nothing etther above or at Street level to account for this extraorúinary occurrence." (RIO) tligh strength and disappearance are not amor® the usual properties of spider's webs. This account resembles those of "ángel hair" in the UFO literature.

X9. October 1969. St. Louis, Missouri. "Great globs of spider-web-like material descended from the sky, alarming numerous citizens. As Donald Pecsok, director of the county's air pollution control división, re- mexnbers hundreds of calis poured into the newspapers and his office. People thought the material was from an exploded test air- plane from nearby McDonnell Douglas plant; thought it w-as from a flying saucer; or thought it was a divine sign, etc. According to nearby rural residents, says Pecsok, tbe globs contained a few eggs oí 'balloon spi- ders, ’ which spun the material at the tops of trees and left it there for the wind to eateb. Unfortunately, most of the material dissolved as it hit the ground. Some that was retained and put under a microscope resembled a spi- derweb, but Pecsok is reluctant to make any great claims because he could not get any local scientists to investígate._____Although the event is listed as a’Spider invasión’, Pecsok notes that he found only one spider, a small browish creature, about an eighth of an inch in diameter and about the size of a quarter with its legs stretched out." At- tributed to the Washington Post, March 28, 1970. Later tests made on the strands indi- cated that it was not of biológical origin^Rll)

X10. Circa May 1973. Near Melbourne, Australia. "A mysterious rain of fine thread fell over the Kilmore area on Satur- day. (Kilmore is 35 miles north of Melbourne.) Farmers said it looked like Bnow as the thread, up to 20 feet long, floatedto earth, carpeting paddocks and hanging from trees, telegraph lines and fences. The elastic, synthetic-type thread stuck to objects and rolled up into balls when gathered. Sheep and cattle were eovered by the mys- tery thread." One report mentioned the presence oí spiders. Attributed to the Melbourne Sun, May 10, 1971. (R12)

Xll. No date or place given. Curious state- ment that auroras are sometí mes accom- panied by the fall of silken threads. (R2) See also GLA17.

X12. April 28, 1957- Woolston, New Zea- land. A mysterious gossamer-like sub- stance floated down upon many of the suburbs of Christchurch. One resident wíth a teleacope found the sky to be ñlled with sheets of the material "the size of a dinner table" From his tele- scope focus-settings, he estimated the highest sheets to be at about an altitude of 15,000 feet.

The potentially anomalous characteris- tic of this "gossamer" material WHB not so much its great quantitv ñor even its remarcable height.

> To the uninitiated it appeared to be spiderweb. But its texture wns very different. When handled it immediately dissolved into nothing; though ap- parently light, it was not light enough to defy grnvity except with the help of a very high wíncL tR13)

Normal spider web does not "dissolve" so readily. Otherwise, ít would be use- less for snagging insects. Could spiders spin a different kind of subliming web just for the purpose o{ "ballooning?

X13. March 12. 1993. South Pacific Ocean. Aboard the m.v, Alam Selamat. At 0630, as a frontal system passed the vessel, there was a sudden rain shower lasting about 25 minutes. Captain J.N, Gowrie reported:

> As the rain began to dry on the warm decks, we noticed patches of what first looked like slime but after it had dried appeared to be wool or cotton. We send you a sample of the material and the facsímile chart of the relevant surface analysis, showing my additions of ship's position at the time as 41° 43'S, 167° 40'W, course 100°, speed 13 knots. (R14)

While not the classical long strands "gossamer," this "flber" fall seems to fit best in this GWF section. The vessel was about 100 miles from lond. Where could these fibera have originated and what was their oomposition? Interestingly, thev díd not sublímate'

XI4. October 25, 1997. Overton Down, England. A uotablv large "eruptíor." of tiny spiders each traiJing long threads oí gossamer. Borne by the wind they were "captured" by o 400-toot high ridge near Overton. Mnny were C8ught and entangled by vegetation. T. Meaden walked across one of their major landing sites and wrote:

"At first, the gossamer was sparse, but 1 was soon in a región which was a verit8ble "field of silk". Over an area of more than two hundred square l?l acres the goBsamer was so dense as to aJmost obscure the grass. It lay in sheets eomposed of millions of sepárete strands made by millions of tiny spiders, of the type that locáis cali 'rnoney- spinners'. When the wind was forcé 1 or 2 the sheets billowed gentíy in the wind llke waves on a white ocean." (R15)

Here the gossamer source is obvious and there is no quick sublimation. The great quantity is interesting but not anomalous.

X15. General observations coneerning that silk y, web-like material called "ángel hair" that eoinetimes falls from the skies. While small spiders often accompany gossamer falls, so also do UFOs! Unlikely though it may seem, ángel hair is a staple of ufology. Could there be a reasonable gossamer-UFO connection?

From a physics standpoint. the answer is "yes". There is a strong pos- sibility that airborne, shiny sheets of entangled gossamer could refleet flashes of light toward an observer when the sun's angle is just right A UFO-inter- prelation is possible.

"Angel hair" from a 1999 UFO event os sean ai 6U.\ through ***o*** *microscope. There* ***is lililí*** *i rseml-lance ta spider qossanur here. (Courtesy P. Budinger)*

Coincident UFO sightings and angel- hair falls cannot pvove a causal re- lationship. However, the UFO waves of 1954 and 1981, partieularly the former. were accompnnied by many joint sightings of UFOs and gossamer falls. Ufolo- gists consider these multitudinous coin- cidences an important proof of a causal connection.

Lastly, the gossamer strands in some large falls apparently vanishes (sublimates?) quickly. This seems to prove that at least some falling gossamer is not spider-produced but might instesd
origínate wíth some UFOs---------or some other still-unrecognized souree! (R16)

For two specifíc ángel hair-UFO reporta, see X1G and X17 following.

It is conceivable, however, that ballooning spiders might spin gossamer strands that have a different composition and thus possees different properties from the sticky, long-lasting strands they use in their webs to catch prey.

X16. October 17, 1952. Oloron, France. "At 12;50 p.m. on a cloudless dey, October 17, 1952, witnesses in Oloron re- ported a long, narrow, white-colored cylinder. In front of this cylinder were an estimated 30 featureless balls. These baila [UFOs?] moved in pairB and tra- veled in a zig-zag fashion. Material fell from them and dropped to the ground, where for severa! hours it covered trees and the roofs of houses?" (R17)

Note the fairly rapid disappearance of the "material."

X17. October 27, 1952. Geillac, France. "Ten days later. at 5:00 p.m., at Gaillac, about 100 people sev* н long plumed [?] cylinder traveling slowly 8mong about 20 saucers. After 20 minutes, the whole spectacle passed over the horizon. However, before it did, masses of white thread fell to earth. The material became gelatinous, sublimed, and disappeared." (R17)

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GWF9 Falls of Miscellaneous Organic Substances

Description. The fall of seeds, berries, feathers, butter-like substances, and various other organic materials. Such falls, like inost others in this section, are usually observed durlng or just after heavy rain or hail.
Background. So great is the variety of organic substances reported to fall from the sky that this eatch-all section must be provided to record the less-common types.
Data Evaluation. Many of the data are oíd and anécdota!; and too many are one- of-a-kind. Yet, there are some basic similarities, such as material and species selectivity. Many, but far from all, GWF9 "falls" are associated with stormy weather. A few bear the marks of hoaxes; e.g., some stones, corn kernels. It's a mixed bag of easily debunked events! Rating: 3.

Anomaly Evaluation. Most of the substances and objects cataloged below are undeniably of terrestrial origin and therefore probably accessible to whirlwinds and tornados. Some, however, Uo take place during fair weather when natural levitating forces are absent. In addition we have these puzzling aspects: (1) The magnitudes of some falls (numbers of Ítems and/or areal extent); and (2) The surprisingly common selectivity and monophyletic nature of many falls. Rating 3.

Possible Explanations. The whirlwind/tornado hypothesis is reasonable in many instances. Rarely, objects and fluids will fall from high-aititude aircraft.
Strong winds can blow particulates and Üquid droplets great distances from their origin in industrial areas that díscharge smoke and vapors. Finally. we have to admit the strong suggestions of hoaxes in some bizarre falls; e.g., some falls of stones and corn kernels.

Similar and Related Phenomena. Colored precipitation (GWP10); anomalous falls of hay and leaves (GWF6); falls of organic substances (GWF9); the long-distance transportation of giant dust partióles (GWF15).

Examples of Falls of Miscellaneous Organic Materials

XI. Circa 1879. Fifeshire. Seotland. After a heavy hailstorm, the hillo were cuv- ered with a substance resembling sea- weed. lt hung from trees and shrubbery. (Rl, R2)

X2. January 31, 1686, Rouden, Germany. A substance called "mourning paper" fell in great quantities. "lt consiated of blaek leaves, having the appearance of burnt paper, but it is harder, co- heres together, is somewhat brittle; and when examíned by Chemical reagents is found to be a mineral mass, composed of the same ingredíents as meteorlc stones; for it consista oí silica, magnesia, iron, and some nickel, and exhibits also traces of chromium. lt may be compared to the blaek crust which covers the surface of the meteoric stones. Black substances, llke beans, are described as having fallen along with this matter, but these bodies have not yet been recognized. " (R3)

X3. August 17, 1841. Lebanon, Tennessee. A shower nf flesh and blood reported Ln a tobáceo field. (R4) A hoax was later admitted. (R5)

X4. No date given. Kentucky. A shower oí flesh (no detalla given) was consideredto have been nostoc. (See GWF7) (R6) But a microscopio examination of the substance proved it to be of animal origin. 1R7)

X5. No date given. Cumberland, Kentucky. "While we were in that land of water-fowl below Cumberland, I wítnessed a shower of feathers; as we sailed up a reach of the river with a fresh breeze, without the know- ledge of a human being within many miles of **UE,** it appeared to be snowing; this was no- thing more than small feathers, and we sup- posed that al some Indian camp in the swamps to windward the operation of goose-plut king must be going on; these feathers had likely travelled many miles, and would continué while the breeze iasted. " (Ró. R9) The

state of Kentucky is assumed here, but the original article dees not specify which of tbe several Cumberlands in the United States is meant.

X6. September 24, 1846. Lyon, France. "On a caltn evening, about sunset, Lortet observed, near Lyon, a thick and rapid shower of fossil Ostracods (Cypridinia), and heard the minute shells rustle the with- ered leaves. They had no doubt beeneaught in an ascending air-ciirrent from some of the regions in North Africa, where they are found." (RIO, RII) Once again, the selec- tIvity of the meteorológica] mechanism is intriguing.

X7. May 9, 1867. Dublin, Ireiand. "Onthe night of May 9, during a violent rainstorm, a remarkable shower of 'berries' feil in Dublin, on botb sides of the river. They were described as having the form of a very small orange, about half an inch in diame- ter, black in colour, and when cut across seeming as if made of some hard dark brown wood. They fell with such forcé that even the pólice were torced to seek shelter. The 'berries' were afterwards identified as ha- zel nuts which had been partially fossilized in a peat bog. How they carne into the air is not known. ” (R12, R13)

X8. No date given. Warminster, England. Fierce wind and haílstorms deposited ivy berries around Westminster and areas within 6 or 8 miles of it. (R14)

X9. No date given. Macerata, Italy. A heavy fall of seeds occurred during a heavy storm, covering the ground up to a depth of about half an inch. One natu- ralist stated they were the seeds of the Judas Tree, found in Central Africa and the Antilles. Some of the seeds had be- gun to germinale. (R15)

X10. April 28, 1893. Jafferabad, India. A fall of seeds simultaneóos with the descent of a meteorite- (R16)

Xll. No date given. Spaln. Wheat fell like rain. Author suggests it was blown over from North Africa. (R17)

X12. March 24, 1840. Rajket, India. A shower of an unknou-n type of grain during a thunderstorm. (R18)

X13. June 24, 1911. Eton, England. "'On the moming of Saturday, June 24, the ground here was found to be cove red with small masses of jelly about as iarge as a pea. The re hnu been a heavy rain on Fri- day night, and it was raíning at 7 a. m., when, so far as 1 could ascertain, the phe- nonienon was first seen. On being examinad microscopically the lumps of jelly tumed out to contain numerous ova of some insect, with an advanced embryo in each. The egg itself is very minute----------an elongated oval 0.0-1 ruin, in length. Yes- terday and the day before many larvae emerged, and were obviously those of some species of Chi roño mus, ibougb color- less, having no hemoglobin, as is the case with the larvae of C. plumosus.Not being an entomologist, 1 am at a loss to under- stand how these egg-masses could have appeared where they did unless they were conveyed by the r3in, as it does not seem likely that the midges would have laidtheir eggs on pavements, gravel patbs, tomb- stones Ve." (R19)

X14. Fall and winter 1695. Cos. Limerick and Típperary, Ireiand. "We have had of late, in the County of Limerick, and Tip- perary, shovvers of a sort of matter like butter or groase, lf one rubs it uponone's hand it wiíl melt, but lay it by the fire and it dríes and grows hard, having a very stinking smell. And thls last night some fell at this place, which l did seo myself this morning. It is gathered into pote and other vessels by soine of the inhabitants of this place. " The preceding account was amplified by the Bishop of Cloyne, wbo described a similar phenomenon occurring in Munster and Leinster, Ireiand. "For a good p3rt of last winter and spring, there fell in several places, a kind of thick dew, which the coimtry people called butter, from the con^istency and colour of it, being soft, clammy, and of a dark yellow. It fell al- ways in the night, and chíefly in moorish low grounds on top of the grass, and often on the thatch of cabins. *Twas seldom observed in the same places twice. It com- monly lay on the earth for near a fortnight without changing its colour, but then dried and turned black.……..It fell in lumps, often as big as the end of one’s finger, very thin and scatteringly. It had a strong, ill scent, somewhat like the smell of churchyards or graves; and indeed we had during most of that season very stinking fogs, some sedi- rnent of which rrught possibly occasion this stinking dew, though 1 will by no means pretend to offer that a reason oí it. " (R2ü) The spelling and punctuation have been modernized to some extent. bee also the blnsiing fogs (GWI)3) and gelatinous me- teors (GVVF7).

X15. September 5 and f., 1978. Washington, D. C. "An unexplained green slime fell on Washington, I). C. , 5 and 6 September 1978. The affected arca is geuerally bounded bv Rock Creek Parkway on the west, Pennsyl- vania Avenue on the north, G Street on the south and 23 rd Street on the east. The slime was discovered injuring plants and animáis, soiling automobile windshields, angering residents and baíflíng eity health officials. About half the flowers in une residente back-yard garden simply wilted and died in the two-day period during which the substance fell." The substance was a green liquid that apparenüy fell from quite aheight because the rooí of a 12-storey buildingwas coated with the substance. (R21)

X16. November 11, 1953. North Atlantic Ocean. The wind coated the lookouts oí S. S. Caxton with a phosphorescent substance that gave off a greenísh glow. It was readily brushed ofí and could be transferred to other objeets. It might have been wind-blown bioluminescent organisms. (R22)

X17. December 1870. Venezuela. After a heavy rain, plant leaves were covered with a great many yellow specks, which microscopic examination proved to be fresh-water plant cells; species Tricera- tium and Cosmarium. (R23)

XI8. Frequent occurrenco. Bath, England. '*í should be very glad if I could obtain infor- matíon as to the cause and nature of certain 'purpie patches' which I have notlced from time to time íor many years past, but hafce been unable to get explained. The patches in question occur during, or immediately after, rain, on the pavement or roadway; dashes of vivid purpie, or rather violet, varying in size from small splashes or drops to patches as largo as the palm of one'shand, but most commonly they are about the size of a sbilling, When quite fresh, sometimes a little clot ís observable in the centre of the splash. Sometimes I fíud one patch eompletely ísolated, sometimes two or three in cióse proximity; sometimes, again, numerous little drops scattered over a certain space; once 1 counted twenty or thirty tiny dashes in about ten yards of pavement. When quite wct the violet colour can be rubbed up with a handkerchief or paper, which it stams as with 'amlinepur- pJe' dye, as it does the pavement. and when once dry it is quite inerasible, and lasts til i it is worn avvay by exposure, or the feet of passers-by. i observe it to occur chiefly during warrn rain after a drv <»r coid spell; never during dry weather, whe- ther in summer or winter. During the past hot summer there was none to be found, bul directly the weather changed in July, I saw it in various localities. Filis was also the case in the long coid winter of 1895, when on the breaking up oí the frost there were plentiful patches to be seen up and down the streets; there was also a complete absence during the following summer, till the drought gave, and then again I found this appearance recur." (R24) One letter to Nature suggested the patches were droppings from berry-eating birds.

(R25) The purpie patches, however, seem to be found all scasons of the year in many localities. But there is probably somo similar prosaic explanation.

X19. 1876. Bath Co., Kentuckv. An extensivo shower of jelly-like substance. Thoughtto be the drted spawn oí fishes or írogs. (R26) See X4, which rnav be the same incident.

X20, May 5, ¡780. San Domingo. "Manna is the bread of organic showers; but what is the meat? Showers of flesh have often been re- corded and they have proved tu be precipita- tions oí a glairy substance, which apon partial dryirvg formed enough of a skin on the oulside lo induce pvople to cali it ilesh. When found fresh, this material has been compared to butter. Probably most if not all of it i;- the material known as zooglea formed on the sur- face of water where bacteria are aetively rnultiplying. The substance known as zoogen or xoiodin is probably the same." (X19 tles- cribed hure) "Such spawn really has raineel down also, if we may beíieve the- account of M. Moreau de St. Mery, relating to an ob- servation in San Domingo. 'From November, 1765, to the 5th day of May, 1766, there was experienced a terrible drought The last day, viz, May 5, 178G, there fell during a strong east wind, in several parts of the city of Port au Prince.... a great quantity of black eggs, which hatched the following day. M. Mozard preserved about 50 of tbese small animáis in a flask half full of water, where they shed their skins several times. They re- sembled tadpoles. (R26i

X21. No date given. Lake Providence, Louls- iana. ”ft is stated that during a heavy thun- der-storm near Lake Providence, Louisiana, a number of small bodies were found on the ground, immediately after the shower . s< alte red along the shore of the Mississippi River for a distance of forty miles ab -ve

the lake; as many as half a bushel being collected around one bousc. These, on being submitted to critical examinaiion, proved ti fjo the scales of the common gar-fish of the South (Lepidosteus). The speeies inhabits the siiallow, muddy waters of the South and sometimes uttains a iength of five or sL\ feet, and is especialJy charaeterízed by being enelosed in an almost impenetrable coat of mail (the scales in questíon), so compact as almost to resist the penetration of a ballet. It is very diffieult to give credence to this story; as the gar-fish are not particu- larly abundant, and the method of aggregation of so large a number of dctached seales would be a problem extremely diffieult of soJution. Perfeetly authentic instances are on record of small fish. shells, etc. , being taken up in storms and scattered over the earth; but when it comes to special portions of fishes which weight from 5 te 50 lbs. each, the draft upon one's failh is rather too severo.'' (R27)

X22. June 8, 1901. Sart lez-Spa, France. On this date, the correspondent of the Meteorológica! Service reported that at about 2 P.M. a liquid substance fell from the sky that was neither rain ñor snow, ñor hail. This liquid stuck to the leaves and niede them sparkle like little mir- rors. Upon closer investjgation, the substance also stuck to one's fingers.

This anomalous precipitation lasted only 5-7 minutes. Ko ciouds could be scen above the village.

It was spi-culated that this sticky material originated in a conflagration at Amers, 140 kilometers away, during which great quantities of sugar hfld been consumed and, perhaps, partly vaporized and discharged into the atmospher» . (R28)

X23. May 1930. Danville, Virginia. Bro- ken seashells fell with hail. (R29)

See GVVF14 for falls of live shellfish.

X24- September 1938. Washington, D.C. "A mysterious green Chemical descended on parts of Foggy Bottom last week, wounding flora and fauna, soíling auto- mobile windshields, angering residents, and baffling city health officials."

Some garden plants were killed. Cats and dogs beeame nauseous.

The liquid appBrently fell from a great height becausc it was found on the roof of a 12-storey building. (R30)

Compare X29, San Francisco's 1994 green rain of airplane deicer. But air-plane deicer is an unlíkely explanation for this 1938 fall at Washington.

X25. July 9, 1984. Brasschaat, belgium. "At Brasschaat (8 km N.E. oi industrial plants at Antwerp), small dark-bluish or purple, jelly-like, sticky fragmenta carne down during severe wind gusts. Aceording to a meteorologist interviewed by Het Volk, they might have been sucked up from a Chemical taetory by levitating witids." (R31)

X26, July 24, 1984. Winton, Bournemouth, United Kingdom. A report from F..J. Hodge. "1 was in my car waiting at trafile lights in Winton, Bournemouth, when a sheet of off-white or dove-gray liquid fell from the blue sky on to the roof, windscreen, and bonnet of my car. A yellow bus nexl to me and the road srotind were also affected." (R32)

X27. December 1989. North Reading, Massachusetts. "Some time between the 12th and I8th of December (1983), the west end of North Reading in Massachusetts was bombarded with blobs of jelly- like goo, greyish-white and oily-smelling.
The first blob—two feet in diameter----------
was found by Thornas Grinley in his driveway. He thought something was leaking from his car until he found similar blobs on Main Street and on the gas station pumps. State officials denied that the blobs were dropped by a plañe. They were soon absorbed into the pave- ment, but a little goo was saved and was being studied at the state's Department of Environmental Quolity Engineering. Preliminary results showed that they were nol toxic." (R33)

However, no precise identification followed, ñor was a source indicated!
Sueh is common in "substance" falls.

See GWF7 for "gelatinous" meteors and pwdre ser, which bear some similar- ity to the above "blobs."

X28. Extended perica in the early 1980s. Evans, Colorado. A series of problemati- eal accounts of small handfuls (10-25) corrí kernels falling on and around houses in Evans. Some individuáis claimed to have actually seen the falling corn. On two occesions, pinto beans rather than corn kernels fell! No uu- usual weather phenomena were in volved. (R34)

This Ítem closely resembles the famuus stoixfe falls ut Chico, California (GWF2-

X30). Hoaxes seem indicated in both series of events. In this instance, the introduction of pinto beans suggestfi a hoaxer at work.

X29. February 17, 1994. San Francisco, California. About 2:30 P.M., sheets of a bright green liquid fell aiong Mission Street. Automobiles and buldings sud- denly turned green. The celestial dye was quiekly washed away and down the gutters by an ensuing rainstorrn, iR35)

The green rain was analyzed and found to be aircraft deicer fluid. It was theorized that it fell from an incoming aircraft that had been deiced at its (colder) point of origín. Some of the deicpr might have collected in the wing flaps and frozen in flight. The descent into warmer California nir melted it.
(R36)

Here, we have a very reasonable explanation.

X30. April 9, 1999. Salt 1 ake Valley, Utah. The following is an itera from an eastern newspaper.

"Maybe it’s a bird, raaybe it's a plañe. But it is certainly sewage.

•'And it’s no joke in the Salt Lake Valley, where gobs of thick, raw sewage falling from the sky a dozen times since April 9 have soiled up to seven houses
at once.” (R37)

"The smell in the area was "terrible" according to the mayor of Taylorsville. Sheriff's deputies were studying the ’splatter pattern’ and firemen were hoslng down the houses. One house re- quired 500 g8llons of water and 30 gal- lons of bleach.

"Aircraft landing at the Salt Lake City airport sometimes pass over the afflicted area, but the Federal Aviation AAminis- tration stated—-as they always do— that jet toilet tanks can only be flushed using an externa! valva, Furthermdre, the bluish disinfectant used in aircraft toilets was not present in the sewage samples."

The repetition of the phenomenon la "dozen" times) in the same area is curi- ous. Assuming that aircraft were al faulí, was o single plañe responsible, or did a dozen have the same defectiva valve? Di«1 this sewage fall really happen?

X31, May 31. 2004Lawrence, New York. **"A** holiday bnat pnrty in an exclusive aren of Long Island was interrupted— when a severed human hand mvsterious- ly dropped out of the sky onto the deck of a boat, pólice said yesterday.”

This gruesome event took place on a boat anchored just off the exclusive Lawrence Village Marina. The hand was not decomposed and was apparently that of a rnale Caucasían. Some speculated that the hand had been severed from a stow-away on an aircraft landing or taking off from J,F Kennedy Airport. the retraction c*r lowering of a plane’e landing gear might have done tha damage. (R38)

Although the tale sounds doubtful, the pólice were apparently involved. However, no further information was fortheoining from them. There shoukl have been something recorded officially!

X32. August 31, 1981. North Wales, United Kingdom. Testimony of Mrs. R. Colegate. "...between 1400 and 1430 hours, my husband and 28-year oíd daughter sew to their nmazement and disbelief earth falling out of the sky in the shape of soda about 6 inebes high which would fit into the palm of your hand, and olhers were larger. There was grasa growing out of one side. The weather at the time was sunny and bright. windv, and orí the cool side. (R39)

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GWF10 Fish Falls

Description. The fall of fish froto the sky. often by the thousands, and usually along with heavy downpours. With rare exceptions, the fish are native to the area and alive when they hit the ground, roofs, and other structures, However, falls of dead, decaying, and dry fish have been reported. FalleD fish average 2-4 inches in length, although specimens up to a foot are on record. The area of a fish fall is typically long and narrow----------a hundred feet to several miles in length.

JQackground. Fish falls have long been ridiculed by the scientific world and debunkers of strange phenomena, even though perfectly reasonable meteorological mechanisms exíst for levitating fish and transporting them long distances.

Data Evaluation. Most reporte of fish "falls'' are really announcements that fish have been found out of thelr element; viz. on dry land or isolated pools of water. Observations of fish in free fall are rare. Nevertheless. the cireumstantial evidence is very strong Ln many instances and when combíned with the high-quality accounts of people seeing fish in the air and even beíng hit by them makes a strong case for the reality oí the phenomenon. Rating: 1.

Anomaly Evaluation. No one argües that whirlwinds, tornados, and waterspouts can pick up objects, earry them long distances, and then release them so that they seem to fall from the sky. There are, however, several anomalies associated with fish talls: (1) The rare falls of dead, decaying, and dried Fish; <2) The frequent species-selectiivity of falls, wherein only one species falls sans plants and environmental debris; (3) The great travel distances as inferred by the falls of alien species native to locations hundreds, even thousands, of miles away; and (4) The large sizes of some fallen fish; i.e., more than 2-3 inches. These facts strain the whirlwínd hypothesis Rating. 3.

Possible Explanations. Whirlwinds, waterspouts, and tomados probably accomit for most fish falls. Even dead and decaying fish along a shore may be picked up and transported. Some instances of supposed fish falls may result from the temporary overflowing of fish- containing bodies of water and the release of fish buried in the mud.

Similar and Related Phenomena. All other falls of living animáis, especially frogs and toads (GWF111.

Exampies of Fish Falls

XI. 689, Saxony, Germany. A rain of fish during a storm. (R34, R35)

X2. Spring 1666. Kent, England. "About Easter, in the year 1666, a pasture fieldin this parish, which is a considerable dis- tance from the sea or any branch of it, and a place where there are no fish ponds but a scarcity of water, was scattered over with small fish, ln quantity about a bushel, supposed to have been ralned down from acloud, there havlng been at that tíme a great tempes! of thunder, hall, wind, etc. These fish were about the size of a man's llttle finger; some were like small whitings, others like sprats, and some smaller like smelts. Several of these fish were shown publically at Maidstone and Dartford." (RIO, R26, R31, R44, R47) One of thd classic accounts. It is typically vague in that it does not say positively that fish were seen to fall-----they were simply lnund on the ground.

X3. 1673. Island of Kolter, Great Britain. Many herring found on mountain top. Whlrlwind postulated. (R34)

X4. 1691. Ecuador. Mud and fish eruptfrom volcano. (Rl)

X5, June 19 and 20, 1698. Ecuador. "When the summlt of the mountain Cargualrazo, to the north of Chimborazo, and 18,000 feet high, fell. ln the ntght between the 19thand 20th of June, 1696, the surrounding fields, to the extent of about 43 English square miles, were covered with mud and fishes...
I recur to these facts, because they throw some light on the difference between the eruption of ashes, and that of mud-like mas- ses of tufa and trass, which contaln wood, coal, and shells.” (Rl, RIO, R26, R31)
This is not an example of a true fish rain, belng geological rather than meteorological, but it does underscore the fací that fish can be deposited on the ground in many ways.

X6. September 2-3, 1771. Cotbus, Germany. Fish 5-6 laches long reported to have fallen during a heavy thunderstorm. (R31) X7. 1795. Lake Muritz, Germany. Heavy shower passed over lake, scattering fish over eurrounding flelds. (R31)
X8. July 25, 1795. Steuer, Germany. <R31)
X9. 1796. Lorn, Great Britain. Herríng fry- (R2, R31)

X10. Círca 1809. Pondicherry. India. "In a heavy shower of rain, wbíle our armywas on the march, a short distance from Pondicherry, a quantlty of small ñsh fell withthe rain, to the astonishment of all. Many of them lodged on the men's hats; when General Smith, who commanded, desired them to be collected, and afterwarda, when we carne to our (camping) ground, they were dreased, making a small dish that was ser- ved up and eaten at the gene ral'a table. They were not flying fish, they were dead, and falling from the common well-known effect of gravity; but how they ascended, or where they existed, I do not pretend to account. " (R31)
Xll. March 1817. Appin, Scotland. After abundant rain, herring fry 1 1/2 to 3 inches in length found scattered over the ground. About 3 barréis full, (R2, R31) X12. 1821. Melford House, Scotland. Shower of large herríng fell during boisterous weather. (R2, R31)
X13. July 1824. Meerut, India. Fish fell on soldiers at drill. (RIO, R17)
X14. Summer 1824. New York, New York. Fish found in the streets. (R47)
X15. 1825. Kinross-shire, Scotland. (R2, RIO, R26, R31)
X16. July 1826. Moradabad, India, láve fish were seen to fall on the grass. (RIO, R17)
X17. May 28, 1828. Kratzburg, Germany. (R31)
X1S April 21, 1828. Strathpeffer, Ireland. Ground covered with herring 3-4 inches long. (R3, RIO, R21, R31, R29)
X19. Summer 1828. Cambridge, Maryland. Large fish were found in rain-fílled dlt- ches 1 mile from a river. (R4, R31)
X20. July 20, 1829. Moradabad, India. Fish were seen flipping about on the grass after a shower; one was 2 1/4 inches long. (R20, R31)

X21. February 19, 1830. Nokulhaity Factory, India. "On the 19th of February, 1830, at noon, a heavy fall of fish occurred at Nokul- hatty Factory, in the Dacca zillah; deposi- tions on the subject were obtained by nlne different partios. The fish were all dead; most of them were large; some were fresh, others rotten and mutilated. They were seen at first in the sky like a flock of birds des- cending rapidly to the ground. There was rain drizzltng at the time, but no storm. " Some of the fish were headless. Some wit- nesses were hit by falling fish; others found them on their roofs. (R6, RIO, R17, R26, R31. R40)

X22. 1830. Dunkeld, Great Britain. (RIO) X23. March 9, 1830. Argyleshire, Great Britain. Small herring scattered over the flelds. (RIO, R26, R44)
X24. May 16 or 17, 1831. Futtehpur, India. After a storm several thousand fish were found strewn over a wide area. They were all dead and dry. (R31) Date for this fall said to be 1833. Some of the fish weighed 3 pounds. (RIO, R17, R26)

X25. 1833. Lake Gwynant, Wales. (R44)
X26. May 1835. Allahabad, India. Dead and dry fish found after storm. (RIO, R17) X27. 1835. Louísville, Kentucky. After a heavy rain, a great number of sun-perch, 2-3 inches long, found swimming in the gutters. (R44) Date given as 1837. (R7) X2S. 1838. Calcutta, India. Fish taken out of a pluviometer. (R17)
X29. September 1839. Calcutta, India. Fish, about 3 inches long, fell in a long straight Une. (RIO, R31) Event occurred on September 20, aceording to R50.
X30. June 30, 1841. Boston, Massachusett6 (?). fine fish 10 inches long with smal- ler specimens. (RIO, R31, R47)
X31. July 8, 1841. Derby, England. Fish and ice fall. (RIO, R31) Frogs also reported to have fallen. (R8)
X32. October 1841. Dunfermline, Great Britain. Many small fish during a heavy thunderstorm. (R9, R34)
X33. Juiy 25, 1850. Kattywar, India. After 35 inches of rain in 26 hours, the ground was literally covered with fish; some on the tops of haystacks. (RIO, R17, R31) X34. August 3, 1852. Poonah, India. Multitudes of fish on ground after heavy rain. (RIO, R17)

X35. February 9, 1859. Aberdare, Great Britain. "'On Wednesday, February 9, Iwas getting out a piece of timber for the purpo&e of setting it for the saw, when I was ¿tartled
by something falling all over me-------dovvn my neck, on my head, and on my back. On put- ting my hand down my neck I was surprised to find they were little fish. By thts Lime I saw the whole ground covered with them. I

took off my hat, the brim of whieh was ful] of them. They were jumping all about. Tbey covered the ground in a long strip about 80 yards by 12, as we measured afterwards. That shed (pointing to a very large workshop) was covered with them, and the shoots were quite full of them. My mates and I might have gathered bucketsful of them, scraping with our hands. " (Eli, R12.R13, R17, R29, R31, R34. R48) J. E. Cray, of the British Museum, thinks it was all a practical joke. (R14) R. Drane, who investigated the fall carefully asserts that it could not have been a practical joke because the fall occurred over a considerable tract of country, with testimony from widely separated areas.
(R1S)

X36. Februarv 20, 21, and 26, 1861. Sing- apore. "When the sun carne out agaln I saw numbers of Malaya and Chínese filling their baskets with fish contained in the pools formed by the rain. They told me the fish had 'fallen from beaven, ’ and three days later, when the pools were all dried up, there were still many dead fish lying about I found them to belong to the C1 arias batracfaus, whieh can live a considerable time out of water, and even move to some distance on dry land. As they lay ín my courtyard, whieh is surrounded by a wali, they could not have been brought in by tbe overflowing of a torrent, ñor is there any considerable one in the neighborhood. The space covered by these fishes might be a- bout fifty acres. They were very lively and seemed to be in good health. "(R16,
R26, R31, R34, R47)

X37. June 9, 1868. Dolitz, Germany, <R31) X38. May 24, 1873. Bremen, Germany. Great number of whitefish. A water- spout was seen in the area. {R31>

X39. Circa 1875. Woodbury, New Jersey. Small fish found flapping about after a heavy rain. (R34)

X40. 1879. Berrybank, Australia. Thou- sands of mínnow'S found swimming in pools left by a ralnetorm. The track of the storm was only 100 yards wide by half a mile long. (R34)

X41. December 15, 1883. Airdric, Scot- land. A shower of live perch, whieh are usualiy deep-water swimmers. (R19)

X42. Circa 1886. Aberdeen, South Dakota. Small fish found on the roofs of office buildings aJtcr hard rain. (R34)

X43. January 24, 1887. Walgett, Australia. Many íish about 3 loches long found in slanding water on a road after heavy storms After the water dried **UD** there were thousands of dead fish counted. (R20)

X44. 1888- Near Líttle Rock, Arkansas. Fish found in ponds that were dry be- fore a heavy rain. (R341 X45. 1889. Steyl-Teegelen, Hotlana. A waterspout formed and then retracted itself into a eloud, disíntegrating with a couple loud detonations. A buge quantity of water and many fish fell immediately after. (R34)

X46. Summcr 1890. Grape Creek, Illinois. Small sunfish and small frogs covered a field after a heavy rain. (R25)

X47. May 29, 1892. Coalburg, Alabama. So many eels fell in a shower that far- mers carne with carts to take them away for fertilizer. (R47) Why only eels?

X48. 1393. Wlnter Park, Florida. Sunfisb 2-4 inches long fell with rain. <R22)

X49. June 15, 1895. Co. Clare, Ireland. Many fish 1 1/2-2 inches long fell with a few drops of rain. (R23)

X50. July 26, 1896. Essen on the Ruhr, Germany. A hailstone the size of a hen's egg contained a crucian carp 40 mm long. (R31, R44)

X51. May 15, 1900. Providence, Rhode Is- land. During a severe thunderstorm, perch and bullpouts 2-4 inches long fell on yards and streels. iK35. R47)

X52. Summer 1900. Buffalo, New York. Street puddles filled with small fish. (R34)

X53. June 27, 1901. Tillers Ferry, South Carolina. Hundreds of little catfish, perch, trout, etc., fell during a heavy rain and were found swimming in the pools between cotton rows. (R24, R26. R31, R47)

X54. April 14, 1909. Newcastle, Natal. "The locality of this rain was near the bor- ough of Newcastle, Natal, and the area covered was about 400 yards long by 100 wide. This area lies between two running streams ----Osborne Spruit, 400 yards away and at about 50 feet lower level, and IndandaRiver, a mile away and about 30 feet below the level of the región where the fishes fell. Ihus there was no possible chanco that the fishes had been brought on the land by an in- uodation. Mr. Nesbit riid not actually uil- ness the fall. since it took place some time between midnight and 6 o'clock of the morn- ing of April 14, 1909, but he did see and pick up some of the fishes alive at 7:30 A. M. on this day. He reported thai there were literally hundreds of fishes, some alive and comparntively unhurt, some dead, and some smashed almost to a pulp. i he largest

fisbes were 3 inches long, the average lengtn about 1.5 inches. There were several kinds of fishes, and Dr. Warren notes that the lar- gest were Barbus gurneyi. " (R34, R36) The varying amounts of damage done to the fisbes is curious. Why are some unhurt whileothers are smashed to a pulp? (WRC)

X55. 1915. Kelantan, Malaya. A terrific thunderstorm; water was ankle-deep in 10 minutes. Many small fish about 1 1/2 inches long seen Ln water covering hard- baked fields. They were not mudfisb be- cause the water ran off before mud was formed. (R34)

X56. August 24, 1918. Hendon, England. ",About 3 o'clock on the aftemoon of Satur- day. August 24 last, the allotment-holders of a small area ln Hendon, a Southern sub- urb of Sunderland, were sheltering in their sheds during a heavy thundershower, wheo they ot>served that small fish were being raiiw-d to the ground. The fish were preclp- italed on three adjolning roads and on the allotment-gardens enclosed by the roads; the rain swept tbem from the roads inte the gutters and from the roofs of the sheds into the spouts.. .. The precipitation of the fish, we were told, lasted about ten minutes, and the area involved Commercial Road, Canon Cocker Street the portion of Ashley Street lyíng between these streets, and the adjoin- ing gardens. The area measured approxi- mately f>0 yards by 30 yards, and was thus about one-third of an acre, It is not easy te say how many fish fell, but from the accounts ít may be gathered the> were numerous; there were apparently several hundreds."
The fish were identified as sand-eels. All were dead when they fell. They were, in fact stiff andhard; and some broke wben they hit the ground. (R27, R2b, R34, R45, R47) lf the sand-eels were dead and stiff the> must have been aloft for rrany minutes, perbaps hours. (WRC)

X57. 1919. Argylshlre, Great Britain. A waterspout burst, precipitating herrings in heaps on pavements and roofs. (R30)

X58. June 11, 1921, Gulf of México. A cloud to which a waterspout had been ai- tached dumped a torrent of water upon a fishing boat. Between 30 and 50 men- hailen 2-3 inches long carne down w'ith the deluge. (R34)

X59. 1924. Gulargambone, Australia. Hun- dreds of small gudgeons founa in the gutters after heavy rain. (R33)

X60. May 29, 1928. Drumhirk. Ireland. After an exceptionally violent thunder storm, dozens of tiny red fish were dis- covered on the roof of a house. (R38)

X61. May 18, 1928. Tarboro, North Carolina. Hundreds of small fish were found swimming ín puddles in the fields after a heavy downpour. (R35)

X62. Juiy 10, 1933. Muzaffapur District, India. (R39)

X63. September 1936. Guam. "While sta- tioned on the island of Guam in September, 193b. I witnessed a brtef rainíall of fish, one of the specimens of which was identified as the tench (Tinca tinca) which, to my knowledge, is common only to the fresh wa- ters of Europe. The presence of thisspec- ies at a lócale so remóte from its normal habitat is worthy of note." (R43)

X64. October 23, 1947. Marksville, Louisi- ana. "A rainíall of fish occurred on October 23, 1947, in Marksville. Louisiana, while 1 was conducting biologicai inv'estígations for the Department of Wild Life and Fisheries.
In the moraing of that day, between seven and eight o'clock, fish ranging from two to nine inches in length fell on the streets and in yards, mystifying the citizens of that Southern town. I was in the restaurant vvith my wife having breakfast, when the waitress informed us that fish were falling from the sky. We went immediately to collect some of the fish. The people in town were excited. The director of the Marksville Bank, J. M. Barham, said he had dlscovered upon arisiog from bed that fish had fallen by hundreds in his yard, and in the adjacent yard of Mrs.
J. W. Joffrion, The cashier of the samebank, J.E. Gremillion, and two raerchants, E. A. Blanchard and J, M. Brouillette, were struck by falling fish as they walked toward their places of business about 7:45 a. m. There were spots on Main Street, in the vícinity of the bank (a half block from the restaurant) averaging one fish per square yard. Auto- mobiles and trucks were running over them. Fish aiso fell on the roofs of houses. " The several species that fell were native to local waters. They were coid when picked up; one person claimed they were frozen. The fish fell ln a strip 75-80 feet wide and about 1,000 feet long. The weaiher was foggy but com-paratively calm. (R42) The calm weather is an unusual aspect of this report. (WRC)

X65. July 13, 1949. Welltngton, New Zea- land. (R45)

X66. 1824. Fífeshire, Great Britain. <R34) X67. No date given. Gulargambone, Australia. Many fish found in gutters after a heavy rain. (R34) Same as X59 ?

X68. No date given. Argentina. It is not unusual for heavy rains Ln tbe Chaco región lo inelude fish íaiis. <R34)

X69. No date given. Shaw, Mississippi. Minnows found swimming between cotton rows after a heavy rain. (R34)

X70. No date given. Galloway, Scotland. A shower of herrlngs. (R2)

X71. No date given. Near París, France. Streets covered with fish up to 6 inches long. <R31)

X72. General observation. In the arctic live fish are occasionally found in dry places. They raay get there during mi- gration, when they often leap (like salmón) over obstructions. (R32)

X73. General comment. Fish found alive in fields did not fall there but were stranded after heavy rains inundated the arcas. (R18)

X74. General comment. Evidence for fish falla is all hearsay. They never occur in fact. (R41) The author of this letter to Science. Bergen Evans, was a well- known debunker of unueual phenomena. (WRC)

X75. Superficial descriptions of the fish- fall phenomenon. {R37, R46)

X76. No date given. Bullía, India. A water- spout broke íind produced heavy rain along with a shower of fish and turtles. (1121)

X77. July D, 1825. Kingwo<>d, New Jersey. A four-inch sunfish, still alive, during a violent rainstorm. (R49)

X78. November 1931. Bordeaux, France. (R51)

X79. January 20, 1936. Flurence, Italy. Fish seen spinning in the air in violent whirlwinds. (R52)

X80. November 1931. Bordeaux, France. "Live perch rained from the sky when 8 waterspout broke over Bordeaux Satur- day.

"The downpour lasted less than 30 secónds, but so manv fish fell wriggling in the streets that motor cars were cotn- pelled to halt after having crushed hun- dreds. The fish were from four to five inehes iong.

"Housewiver- with baskets and basins picked up nil that they could find before they were swept down the drains." (R53)

X81. 1912. Muzaffarpm- District, India. G.T Gilí WBB the observar of several fish falls is this part of northeastern india near the Nepfli border. When cotn- mentinsr on the 1933 Indian fish falls

"___nothing as compeled with the one which occurred nt Bunhai Faetory in 1912, where 1 then was, 1 actually ob- served this with my own eyes, that is to say when the rain was actually falling I did not notice fish coming down with it, but the rain, which was very heavy, ceased very suddenly, just like the rain on the lOth July last [1933], and when it did, my tennis lawn and the road in front of the bungalow were simply white with mounds of fish, so much so that at first, before 1 went outside to investígate the matter, 1 thought it must be hall lying on the ground. To my nmaze- ment 1 saw it was fish. They were also all over the indigo faetory which was one-third of a mile from the bungalow. None of the fish were of anv size, none of them being more than two ínches long." (R54)

Gilí also referred to other well- observed fish falls that occurred in the same aren since 1912. He testified that in snme falls there were several species of fish, thus contradicting the common assertion that fish falls are monophyletic.

X82. July 11 to September 1, 1933. Muzaffarpur District. India. Thes*- fish falls were surpassed by that of 1911' (X81), as now confirmed by S L Hora.

"The recent falls were not so big but píenty of fish were to be had for the pickíng up. What is the explanation? My correspondence suggests that the fish ivere sucked up out of a river by a waterspout and then dischnrged agidn during a heavy thunderstorm. The ob- jection to this theory is best put by means of a question. Where are the fi*h in the interval between the breaking up of the water-spout and tbe thunderstorm? What ktepr them suspended in the air?" (R541

X83. Spring, no yesr given. Thunder Bay. Lake Hurón. ʳi he engaging tale nf a smelt storm.

"It happened during a smelt storm in early spring with the Rhonda K founder- ing dead in the ley water amid terrifying six- and eight-foot waves off Lake Huron’s Thunder Hay light neai Alpena."

"Spookiest thing 1 even saw." Stiles said of the small fish carried from the water by the winds. 'Something I m>ver heard of before. Smelt started falling from the sky. Thousands of smelt falling like a süver rain, and thousands

all around our heads picking up the smelt." (R55)

X84. About May 16. 1983. Chippenham, England. A group ni students at Chippenham TechnicaJ College reportad that a lot of tadpoles had fallen during a thunderstorm. The river Avon is nearbv; 8nd a waterspout or small tornado was suspected. (R56)

Of coursp, tadpoles are not fish, although there is .some reserobla¡ice, so we dutifullv add this to the legitimate tadpole falls in GWF11.

X85. March 1989. Rosemont, Australia. A widespread fall of sardines "like a sheet of silver rain." They were all dead. Soroe hit H. Degan on the head. The kookaburras gobbled them up, but the faroily cat wouldn't touch them. (R57)

Cats not eating sardines? That seeros anomalous!

X86. About 1997. Somewhere in the U.S. We copy hero the caption beneath a re- mnrkabie photograph from the February 1998 íssue of (jST, a magazine for radio arnateu rs.

"When Dave, K1WHS. checked the SWR of ívs 432-MHz beain last spring, he could tell that something was wrong---------- it was much higher than normal. From the ground he thought he could see soniething dangling in the elempnts. Upon closer inspection he discovered the desiccated remains of a catfish! No one knows how the hapless catfish ended up 60 feet in the air, and miles from ony lake or stream." (R58)

While the catfish probably did fall from the sky, it was most líkely dropped by an osprey or some other large fish- eating bird.

X87. May 31, 2000. Ethiopia. In Southern, drought-stricken Ethiopia, the struggling farmers were treated to a deluge of fish.

"The unusual rain of fish. which dropped in millions from the air—some dead and others stili struggling----------created panic aroong the mostly religious farmers." (R59)

Storros in the Indian Ocean were said to be the sourre of the fish----------the usual explanation-----but the numbers claimed are iropressive.

X88. August 2000, Greot Yarmouth, United Kingdom. "Britein's Meteorológica! Office said a shower of dead, but stili fresh, sprats rained down on the fishing port of Grent Yarmouth, in eastern England. after a thunderstorm. The baby fish fell more than a kilometre inland, on the liouses behirid the resort's sea- front, lining lawns and pathways with bite-size sprats.[1]' (R60)

X89. 2002. Korona. Greece. (A trans- lation from the Austrian newspaper Kurier by O. Stummer) After o henvy storm, it rained sardines ín northern Greece. A whirlwind had sucked water out of the sea at Thessaloniki and car- ried the tiny fish along several kilo- meters into the interior. "We could not believe our eyes. The fields and woods were covered with tiny fish," reported an inhabitant of the village of Korona. (R61)

We enter this example to ¡Ilustróte that the foreign-language literuture siso contains many accounts of fish falls.

X90. February 1994. Dunmarra, Northern Territory, Australia. There were two notable fish falls around Dunmarra in February. The seeond is the more in- teresting.

"This seeond flight of fish were up to 4 in. (10 cm)-long and proved to be the freshwater spangled grunter pre- viously mentioned. Ashley Patterson, sénior forecasler at the Darwin Bureau of Meteorology, trotted out the minitornado theory, but admitted in this case it seemed o little lame as Lake Woods, the nearest sizeable body of water is more than 65 miles (100 km) away." (R62)

The distante from the probable source is. of course, what makes this example verge on the anomalous.

X91. April or May 1950. Chilotchee, Alabaros, The weather was clear and hot with a slight westerlv breeze. No tornados or whirlwinds were in the aren.

"The witness and her husband were surprized to notic-e a small and very dark cloud form in the sky. The dark cloud was almost overhead when it star- ted to rain, the rain falling in a very localized area about 200 fe.->i square. As the rain continued, the cloud changed in color from very dark to almost white. The witness and her husband actually saw fish falling with the rain, which lasted for about 15 minutes. The íish

were alive and ílopped about on the gTound. As the rain stopped, the oloud oompletely dissipated.

"The fish that fell were of three types: cotfish. bHss, and brim, al] in- digenous to the aren and all freshwater fish. There were enough fish lo fill n #3 washtub. (A #3 washtub is 3 feet in diameter and about a foot deep.)" (R63)

This is one of the rare cases where the fish are aetually seen to fall.

X92. June 11, 1938. Queenston, Ontario. "On the morning of June 11, fnrm- workers in Queenston. Ontario, found thousands of fish, frorn two to three inches long, strewn about the orchard of Colonel Harold C. Sheppard. A heavy rain had fallen the night before. Many of the fish were loriged in the branches of fruit trees. A hundred were found alive." (R64)

The full article (RG4) relates ten additional fish fatls in the same general area fror.i 1859 to 1940.

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GWF11 Falls of Frogs and Toads

Description. The desceñí of frogs or toads írom the sky, usually by the hundreds or tñou- sands. Frog and toad faUs are inevitably associated with heavy summer rainstorms. The faJling animáis are usuallv alive, aJthough some die upen impact, and average about a half inch In length. These falls are generally ”pure"; that is, not accompanied by other aquatic species or plant debris.
Data Evaluation. Rather surprisingly, many very good cases of frog/toad falls are on record, althougb they tend to be concentrated in the Nineteenth Century, when Science openly dis- cussed such events without fear of ridicule. While the bulk of the cases involve animáis actu- ally seen in flight, some reports may be due to population e.xploslons and mass migrations, wfth no actual levitalion involved. Rating: 1.
Anomaly Evaluation. As in tbe case of fish falls (GWF10), whirlwinds, waterspouts, and tornados are believable meteorológica! mechanisms for collecting and transporting small frogs and toads. The anomalous features of this phenomenon are: (1) The very large number of individuáis involved, which infers that the levitatíng mechanism must strip very large areas of toad/frog habitat and then concéntrate its cargo; (2) The selectivity oí tbe phenomenon; í.e., the general lack of debris and other species typical of the animáis’ habitat.
Rating: 3.
Possible Explanations. The conventional explanation—whirlwinds, waterspouts, tornados ----seems the only reasonable one ai this time.
Similar and Related Phenomena. The other animal falls in this section, particularly fish (GWF10); turtles and shellfish (GWF14).

Examples of Falls of Frogs and Toads

XI. Summer 1794. Lalain, France. "It was very hot. Suddenly, at about 3 o’clock in the afternoon, there fell such an abundance of rain that 150 men of the grand guard. in onler not to be submerged, were obliged to leave a large depression in which they were hidden. But whal w‘as their surprise when there began to fall on the ground all about a considerable number of toads, the size of hazelnuts, which began to jump about in ev- ery direction. M. Gayet, who could not be- lieve that these myriads of reptiles fell with the rain, stretched out his handkerchief at the height of a man, his comrades holding the corners; they caught a considerable number of toads, most of which had the posterior part elongated into a tail, that is to say, in the tadpole State. During this rain storm, which lasted about half an hour, the men oí the grand guard felt very distinctly on their hais and on their clothing the blows struck by the failing toads. As a fiual proof of the reality ot this phenomenon, M. Gayet reports that after the storm the three-cornered hats of the men of the guard held ín their folds some of the reptiles. " (R18)

X2. August 1604. iNear Toulouse, France. ’’Many accounts of showers of frogs have been reporte»! to the French Academy. In August, 1804, two gentlemen, retuming from Toulouse, noticed a black cloud, which burst upon them, and they were surpriseetto see an immense shower of frogs, which fell on their cloaks and covered the roari and the fields, so that a diligence passing along killed a large number. " (Rll)

X3. 1804. Windham, Connecticut. (R21)
X4. June 23, 1809. France. Little toads, the size of hazelnuts, fell during a rain storm. (R18)
X5. August 1814. Fremon, France, During a storm with strong winds. Small frogs fell upon peopJe. (R18)
X6. August 1822. France. A heavy shower of large raindrops albo brought toads the size of walnuts. Some of the toads fell upon the hat of the observer. (R18)
X7. Circa 1830. Bushmills, F.ngland. A shower of half-formed frogs. No rain menlioned. (Rl)
X8. Circa 1830. Rouen, France. Innumerable small, perfectly formed, frogs fell on roofs, window sills, and walks. (Rl)

X9. June 1833- Jouy, France. ”1 saw toads fallmg from the sky; they struck my um- brelln; 1 saw them bopping on the pavement, during .ibuui 10 minutes in which time the drops of water were not more numerous than the toads. The space upon which Isnw

the multitude oí these animáis was about 200 íathoms." (R18)

X10. July 30, 1838. London, England. Af- ter a heavy shower dozens of youngfrogs were discovered hopping on the pavement. (R12)

XI1. June 1841. Tutbury, England. A shower of frogs fell during a severe thunder- storm, They fell in countless numbers írom the housetops. (flll)

X12. 1841. Derby, England. A heavy thun- derstorm deposits hundreds of fish and frogs along with half-melted ice. Many of the frogs were killed by the impaet. (R2)

X13. 1814. Selby, England. "In the eourse c»f the aíternoon of Monday last, during the prevalence of rather heavy rain, the good people of Selby were astonished at a remark- able phenomenon. it was rendered forcibly apparent, that with the descent *of* the rain, there was a shower of another description, viz., *a* shower oí frogs. The truth of this was rendered more manifest by the circum- stance that severa! of the frogs were caught in their descent by holding out hats for that purpose. They were about the size of a horse-hean, and remarkably lively after their aerial but wingless flight. The same phenomenon was observed ín the immediate neighborhood." (R3, RIO)

X14. Summer 1846. Humber River, England. Frogs fell on vessels in the river and the coast near Killinghome lights. (R18)

X15. 1847. Venton, France. A shower of toads. (R'l)

X16. 1859. Waveney River, England. "I was out insect-catching by the side of the river Waveney, about a quarter-past 9 on Friday night, wben a thunderstorm eame on. I ran for shelter to the buildings at Aldeby Hall. The rain carne down in torrents. Just before I was clear of the fens I observed eome small toads on my arms, and severa! fell in mynet, and on the ground and paths there werethou- sands. I am quite sure there were none in my net before 1 started, as I took out a Leu- cania pudorina out of it. I believe they fell with the rain out of the clouds. " (R5)

X17. 1860s. Briton Ferry, Great Britaln. Shower of frogs. (R15)

X18. 1864. Pontiac, Michigan. A small green frog found in a hailstone. (R6)

X19. August 12, 1871. No place given. A shower of small green frogs. (R7)

X20. July 1873. Kansas City, Missouri. A shower of frogs darkened the air and covered the ground for a long distance. (R9)

X21. June 16, 1882. Dubuque, Iowa. Small. still-living frogs found in haílslones. <R8)

X22. Summer 1890. Grape Creek. Illinois. After a heavy rain, the ground was co- vered witb small percb and frogs 3/4 to 1 inch long.

X23. Circa 1891. Bournemouth, England. "One day we had a violent thunderstorm. Having no shelter, I was wet to the skin m a few minutes, and saw small yellow frogs, about the aize of a florín or half-crown. dashed on the ground all around me. I ran to shelter under a large mortar-pan, and, after the storm was over, found ín this pan hundreds of these small frogs.. .Tbousands were impaled on the furze bushes on the common cióse by, and days afterwards the stench from the decomposmg bodies was very noticable. " (R14)

X24. June 30, 1892. Moseley, England. A furious storm brought a shower of nearly white frogs. (RÍ8)

X25. Circa 1894. Dunfermline, Great Brit- ain, (RIO)

X26. August 1894. Thatto Heath, England. Great numbers of frogs or toads found on the ground after a rain. (Ril, R24) X27. 1901. New York City. Tadpoles. (R21) X28. 1911. Twickeuham, England. Tadpoles found in a rain bar reí. (R13) A weak bit of evidence. (WRC)

X29. May 25, 1915. Gibraltar. "During a thunderstorm near Gibraltar on May 25, a cloud ís said to have belched fortb millíons of small frogs which had apparently been drawn up from a lake twenty miles away." (R16)

X30. July 21, 1933. North Chelmsford, Massachusetts. Shower of small toads. (R21)

X31. June 16, 1939. Trowbrídge, England. "Mr. E. Ettles, superintendent of the municipal swimming pool stated that about 4.30 p. m. be was caught in a heavy shower of rain and, while huerying to shelter, heard behind hiraa sound as of the falling of lumps of mud. Turning, he was amazed to see hundreds of tiny frogs falling on the concrete patb around the bath. Later, many more were found to have fallen on the grass near- by. " (R19-R21, R25)

X32. July 26, 1947. Towyn, Great Britaln. Frog fall. (R20)

X33. August 28, 1977. Canet-Plage, France. Tbousands of frogs, the si/.e of peas, fell just prior to a heavy rain shower. (R22)

X34. No date given. Ham, France. A state- ment by M. Peltíer. "I cite an incident I observed Ln my youth; a storm advanced on the little village of Ham. Department of the Somme, where 1 lived, and 1 observed íts menacing march, when suddenly rain fell in torrente. 1 saw the village aquare covered everyvvhere with little toads. Astonished by this sight, i held out my hand and wasstruck by several of the reptiles. The dooryard was also covered; 1 saw them fall upon the slate roof and rebound to tbe pavement. — Whatever the difficulty of explaining the transport of the reptiles, I affírm, without doubt the fact which made such a profound impression upon my memory. ” (R18) The observer may have been the sc-ientist Pelt- ier, but this has not yet been established definitely.

X35. No date given. Godalming, Greai Brit- ain.
The town was swarming with small black frogs. Inhabitants said that they had come with the rain. (Rll) Popula- tion explosiona can often aeeount for the sudden appearance of large numbers of animáis. Some specíes mature and mi- grate in íncredible numbers.

X36, 1834. France. (R23) Same as X4 ?

X37. 1922. Chnlon-sur-Saone, France.
Frog fall disproved. Due to migrating swarms of frogs. (R24)

X38. June 24, 1979. Bedford, England,
Fall of small frogs. Tornados reported

X39. October 20, 1334. Ham, France. Circa 1800, aecording to M, Peltier, testifying at a meeting of the Acadetny of Sciences, París, in 1834, his home town *oí* Ham was hit was a severe storm. The rain fell in torrents, "He then saw the market-place, or 'place de la ville,' covered with little toads. Astonished at what he saw, he stretched forth his hand, and recelved on ít the shock of a number of these creatures. The court- yard of the house was filled in the same manner as lhe 'place.' lie saw them rail on a roof of slates, and thence rebound on the pavement." (R26)

X40. September 1804. Senlis, France. Daylight was suddenly obscured by an enormous black cloud, "A clap of thun- der of extraordinary forcé broke the cloud, which poured upon us a torrent of toads, mingled with a little rain." (R26)

X41. August 1804. Fremard, France.
M. Duparcque, in a letter to the Aeade- mie des Sciences, described a violent storm in which little toads fell in great numbers upon the village as well as him- self and the village cúrate who was accompanying him. (R26)

X42. December 6, 1883. Haití. A corre- spondent of La Nature wi’ote that on this date toads rained down upon the plain of Miragoane. (R27)

X43. June 16, 1937. Frackville, Pennsyl- vania. "Astonished householders of this little mining town, ten miles north of Pottsville, went out with brooms and swept bullfrogs off their open porches after a thunderstorm today.

"The tiny frogs sounded like the thudding of hailstones us they dropped by hundreds on tin loofs." (R28)

The "bullfrog" identification is ques- tionable in this instance. They were doubtless frogs íhough.

As usual the whirlwind theory was advanced to explain the írog fall. It is hard to imagine, bowever, huw hundreds of dispersad tiny frogs can be "va- cuumed up" without also levitating plant debris and other marsh dwellers elong with them.

X44. May 19? 1 . Nafplion, Greece. The inhabitants of this town woke up to finó it raining thousands of little green frogs. Scientists at the Athens Meteorológica! Instituto opíned that they were sucked up from North African marshes and carried by winds 500-600 miles across the Mediterranean. The frogs were remarkably sound and most were uninjured by the iong flight. (R29)

X45. May 16, 1983. Chippenham, Wilt- shire, England. Students at the Chippenham Technieal College reported the fall of many tadpoles during a thunderstorm. (R30)

A whirlwind could be a reasonable explanation here since the Avon river was nearby.

X46. Suramer 1919. Northamptonshire, England. J.W. Roberts recalls a boy- hood experience in the Journal of Meteo- roiogy.

"I saw a dark, aJmost black, cloud coming towards me. lt was a whirlwind.
It picked up some of the loose straw laying Bbout. and when it reached the

buiidings it seemed to stop, and the dark eloud suddenly fell down and I was smothered all over with sroall frogs---------- thousands of them about Ü to li inches long(R31)

X47. Summer 1932. Rodé, Somerset, Eng- land. A myriad of tiny frogs fell upon a farmboy and his dog. (R32)

X48. June 1949. Near Gallup, New México. His reading of our Handbook of Un- usual Natural Phenomena encouraged R.A. Sehuler to write (somewhat vividly) of an experience he and his wife had.

They were driving on Route 66. The tenriperature was 104° F; the sky was blue from horizon to horizon.

"Out of nowhere---without warning— it poured, extremely hard rain, hail and toads. The hail balls were maybe the size of grapes to the size of peas.

"The toada were a médium brown in color and approx. the bize of an adult's thumb nail.

"This whole incident lasted for less than 5 minutes, if iny memorv is correct.

"After u short period of time, maybe one or two miles, we (my wife and 1) ran inte [another] tremendous rain and hail storrn.

"The highway and the desert sands sreined to be alive and moving.

"By now we were down to a very slow speed and under closer observatíon we noticed the area was littered with mil- lions of hailstones and those toads were hopping «11 over.

"The storm stopped as fast as it started, and the toads disappeared just as fast.

" I' 11 never íorget how slippery the ruad was as we drove over those toads and the popping of their bodies under the tires of my automobile." (R33)

The standard explanation of such sud- den appearances of toads in raingtorms is that the rain brings them out of hiding for mating purposes, Bul the writer above States that it "rained" toads. It docs seem. however, that the toads carne out of hiding very quickly and in numbers exceeding a rensonable population density for a desert area.
We favor here, therefore, a "fail" rather than an "emergence "

X49. October 1987. Stroud, Gloueester- shire, United Kingdom. Perhaps most remarkable about this example of a "fall" is that it was printed in the main- stream journal Weather.

"Bemused locáis were not only stun- ned to wítness frogs raining from the sky, b\it also these frogs were pink! Startled scientists identified them as a rare albino strain indigenous to Southern Spain and North Africa, speculating that they were carried there by the same high-level winds that occasionally leave our car windshields with a sprinkling of Saharari sand." (R34)

The transportation of light-weight, exotic species hundred of miles by strong winds is not as anomalous as the wind's careful seleetion and collec- tion en rnasse of a single species minus traces of any of the other light-weight fauna and flora of its native habitat.
How is this selection process accom- plished?

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GWF12 Insect Falls

Description. The fall of flightless inseets from the sky. Worms and caterpillars are the most common occupants of this category.

Data Evaluatiop. Only a few accounts of rather poor quality exist. Some cases are suspect because some insect species migrate in immense numbers and shed their wings ímmediatelv upen landing. Tbere are as a consequence many opportunities for labelling natural insect movements as "falls. " Rating: 3.

AnomaJy Evaluatíon. Since inseets may appear in great profusión and are very light inweighF wind transport is a reasonable explanation in almost all cases; and insect falls are really more curiosities than anomalies. Rating: 3.

Possible Explanations. Whirlwinds, waterspouts, tornados, and even strong, non-rotating winds seem adequate here.

Similar and Related Phenomena. Other animal falls in this section (GWF). Insect population explosiona (BI).

CWF12 INSECT FALLS

Examples of Insect Falls

Xl. June 1819. Riga. Latvia. "During a strong north west wlnd, an immense quanti- ty of young caterpillars fell upt>n the great meadows on the South bank of the Duna, and devoured the grasa, with the roots, upon a very extensive tract." (Rl) A classic case, but one in which the word "fell" might only mean "appeared."

X2. November 1654. Turin, Italy. Severa! thousand insects, both larvae and adults, fell during a violent wind. There were a speeies of hemiptera known only on Sar - dinia, (R7)

X3. May 1871. Dath. England. "A most vio- Jent storm of rain, hail, and lightning visited Bath on Saturday night. The rain descended in torrcnts. causing the Avon to overflowits banks in the lower districts. especiaJlv at SaJford, where whole tracts of land were laid under water. The storm was accompa- níed by a similar phenomenon to that of the previous Sunday; myriads of small annelidae endosad in patches *oí* gelatinoue substance, failing with the rain and covering the ground. These have been microscopically exainined, and show, under a powerful lens, animáis with barrel-formed bodles, the motion of the viscera in which is perfectly visible, with locust-shaped heads bearing long an- tennae, and with pectoral and caudal íinlike feet. They are each and inch and a half long, and may be seen by the curious at Mr. R. Butler's, The Derby and Midland Tavern, where scientific men, on inspecting them, pronounce them to be marine insects, prob- ably caught up into the clouds by a water- spout in the Bristol Channel." (R2)

X4. July 25, 1872. Bucharest, Romanía. "A letter from Bucharest, given in the Le- vant Times, reports a curious atmospheric phenomenon which oceurred there on the 25th of July, -it a quarter past nine in the evening. During the day the heat was stifling, and the sky cloudless. Towards nine o'clock a small cloud appeared on the horizon, and a quarter of an hour afterwards rain bcgan to fall, when. to the horror of everybody, it was found to consist of black worms of the size of an ordinary fly. All the streets were strewn with these curious animáis. "ÍR3, RIO)

X5. Circa 1897. Hutchinson, Minnesota. A luminous cloud "rose majestícally frcm the eastern horizon, shown with a uniform, vivid whitish light and passed directly over the town, When the cloud was overhead a great shower of insecls descended to earth covering the ground all around to the number of about 50 to 100 per square foot. These insects proved to be a speeies of hemiptera and were nonluminous. They had apparently been induced to take wing by the bright ob- ject in the sky. "<R5j Since these insects were winged, it is the possíble association with the cloud that is of interest here.

X6. No dates given, Galatz and Bucharest. Romanía. |R4)

X7. October 14, 1934. Rock Creek, British Columbia, Cañada. "It rained beetles at Rock Creek, B. C., Oct. 14. The downpour of tinv brown insects lasted intermittently for three hours. The beetles had wings, but seemed umable to use them. " iRG)
Another weak example, obvíously.

X8. July 21, 1887. Nancy, France. To- ward 5 o'elock in the afternoon, a veri- table rain of a speeies of forest «nt swept down on the streets and places of Nancy. Both winged and winglesa ants fell like clouds of snowflakes for huurs. The phenomenon was attributed to whirl- winds that preceded a great storm that arrived that night. (R8)

Since some of the ants were said to be wingloss, tbis event is classified as a "fall" rather than a common cloud of winged ants on rnating flights. However, since most ants on rnating flights discard their wings upon alightíng, this entry remains suspeet, Observers could have only assumed that some of the failing anta were wjngless.

X9. February 15, 1950. Innsbruck, Austria. About 9:30 A.M., a Citizen was walking from Wattens to Kolsass when he encounted a heavy snow shower. Failing with the flakes were thousands of small. dark caterpillars, 1.5-2.0 centi- meters long. They were hairy and felt like velvet to the touch. For at least 300 meters, the fallen snow was dark with them. They turned out to be the larvae of loca] insects called Weich- kaefers. (R9)

The lnrvae were flightless and seen to fall with the snow. They were pre- sumerf to have been levitated by the usual whirlwinds.

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(X4)

GWF13 Bird Falls

Description. The fall of Uve or dead birds from the sky. Bird falls are usually associaíed with severe weather conditious. During spring and fall migrations, many birds are killed by impact with tall buíldings, TV antennas, and other obstructions. Except for a couple extreme cases, which may involve anomalous factors, such normal bird mortalíty is exclu- ded here.

Background. We consider birds to be masters of the air, but it is obvious that they aresome- times overwhelmed by the elememts and have their navigational senses confused, resulting in immense numbers being killed.

Data Evaluation. Excluding the common repoi'ts of dead birds found around tall obstructions during migration leavesonlya few díffícult-to-explain cases, many of which come from sus- pect sources. Rating: 2.

Anomaly Evaluation. Most of the bird falls or kills described below seem understandable in the context of severe weather and, though huge numbers of birds are involved, they are more curious than anomalous. Examples XI, X3, and X6, however, have puzzling charac- teristics that make the "weather" explanation seem simplistic. Rating: 3.

Possible Explanations. Dead birds found around tall obstructions typify "impact kills" and need no further explanation. Dead birds fclling from an unobstructed sky are frequently found to have suffered decompression effects and were probably carried to great heights by storms. Lightning has also been advanced as a factor in some bird falls.

Similar and Related Phenomena. None.

Examples of Bird Falls

XI. 1896. Eaton Rouge Louisiana. "On Fri- day morning last early risers in the little capital witnessed a peculiar sight in the shape of a shower of birds that tell Irom a clt-ar sky', literally clutter¡ng the streets of the City. There were wlld dueks, catbirds, woodpeckers, aixl many birds oí strange plumage, some of them resembling caftanes, but all dead, falling in heaps along the tbo- roughfares, the singular phenomenon attrac- ting many spectators and causing much com- raent- " üt the neighborhood of National Aven- ue, children collected 200 birds. (Rl)

X2. March 20, 1941.'Shreveport, Louisiana. "Blackbirds by the hundreds dropped dead fron» the sky at Barksdale Field. They clut- tered the army airbase so thickly that its pólice were called out to clear the ground. A soldier said lirge flocks uf the birds broke flight suddenly and plopped to the ground." (R2)

X3. March 13-14, 1904. Minnesota. "Ro- berts tells the fate of migrating Lapland Longspurs on the night of March 13-14, 1904, which 'was very dark but not coid, and a heavy, wet snow was falling with but little wind stirring. Migrating Longspurs carne from the lowa praries in a vast horde, and from 11 P. M. until morning, incredible numbers met their deaths in and about vi 11 ages by flying against buildings, electric light peles and wires, and by dashing themselves for- cíbly onto the frozen ground and ice.' In Wr t -

thington, Minnesota, an attempt was made te* compute the numbers lying dead on two lakes with an aggregate area oí about two square miles. 'A conservative estímate showed tbat the re were at least 750,000 dead Longspurs lying on the two lakes alone I* The total area on which dead migrants were found covered approximately 1,500 square miles." (R3) AJthough some of the birds apparently flew into obstructions, the great majority seems to have been found on relatively featureless terrain. (WRC)

X4. December 13, 1928. Caliente, Nevada. "During an early morning bour (about 2 A. M.) of December 13, 1928, residente of Caliente, Nevada, were awakened by a heavy thumping of something falling on the roofs of their houses. Those who were eurious enough to step outside and investígate the unusual oc- curence found scores of water birds in the new fallen snow. The next morning, severa! thousand Eared Grebes were found on the ground and on fíat roofs of business houses
throughout the city-----literally thousands of these birds were found in every portion of the lown and outskirts.... they were forced out of the aír by the heavy density of the snow,... Caliente had the maín bunch, but they were scattered for twenty miles every way." Hundreds more were discov- ered in various spots in Utah. (R3)

X5. October 7-8, 1954. Warner Robins Air Forcé Base, Georgia. "On the night uf October 7-b, 1954, the largest recorded ceilo- meter kill in history occurred at Warner Robbins Air Forcé Base, a few miles South of Macón, Georgia. It ínvolved 53 species and an estirnated 50,000 birds, 2552 of which were examined— . An advancing coid front in the autumn is believed to have pre- cipitated these mass mortal ities by bringing together adverse weather eonditions (espec- ially a lowered cloud ceiling), nocturnal migrants, ceilometers and/or tall obstructions. [1] (R4) These is an extreme example of bird kills that take place around obstructions during every migration period. (WRC)

X6. January 25, 1969. St. Mary's City, Maryland. "On Jan. 25, 1969, something smashed up flocks oí ducks flying over Maryland so that their dead and dying bodies rained down around the Southern Maryland community of St. Mary's City (about 50 miles SE of Washington, D. C.) Canvasbacks, red- heads and scaups were found scattered a- round St. Mary's City, on the local college campus, in the St. Mary's River and evenln the downtown business section. The ducks had sustained widespread hemorrhages and múltiple rib fractures. " Attríbuted to the Washington Post of January 20, 1969. (R5)

X7. January 3, 1978. Countv of Norfolk, England. "136 pink-footed geese were killed in Qight in the county of Norfolk. They drop- ped dead out of the clouds along a track 45 km in length, orientated WNW to ESE be- tween Castleacre and Swardeston. Their deaths occurred at the saíne time as a tor- nado-bearing coid front was sweeping south- eastwards across East Anglia. " Autopsies showed extensive hemorrhagíng of the lungs, ruptured livers, and massive ¡ntemal frac- ures and bone damage. It was postulated that the decompression effeets experienced in a tomado and falls from a great height could account for all the damage noted.
(R0)

X8. November 1973. Stuttgart, Arkansas. "On the day after Thanksgiving, hefty. maturo mallards carne crashing out of thesky. Many oí them were frozen stiff.... The day the ducks carne tumbling down was a wild and turbuleut one Ln Arkansas. Severa! twis- ters were sighted over the State and se ve ral touched down amid viulent springlike thun- derstorms, wind tlurries and hail storms.
___'lt was about 4 PM,' said Lloyd McCol- lum, chairman of the State Game & Fish Commission, who lives here. 'Within 10 tu 15 minutes all of them had come down, al) mature, fairly heavy ducks.' The ducks carne dowm with a lot of hail and several were completely ice- encrusted, according to witnesses. Possibly they may have been picked up higher than normal and frozen along with the hail. 'They got up there in colder atmosphere and, like an airplane, got iced over,' Mr. McCoilum said. 'They got ice on their wings and eouldn't fly. In short, they just fro/e to death.'" (R7)

X9. December 10, 1991. MinersviJle, Utah. About 9:30 P.M,, the skies of MinersviJle were filled with the cries of grebes. According to V. Hollingshead: "They were]ust falling out of the sky, hitting the church. cars, the ball parks. Hundreds of them fell all over the streets. You could hear them hitting each other in the air and hitting the ground."

Minersville Elementary School Secre- tary S. Taylor reported that the birds landed everywhere, including the roofs of houses; they even broke sotne nuto- mobíle windshieids. Hundreds were killed, but many survived their fall and were taken to bodies of water where

they eould rest and take off. (Grebes cannot take off from 1Aanil.)

The birds were identified as F.ared Grebes, which were migrating from Great Salí Lake to Baja California.
It was theorized that a snowstorm and fog had exhausted and disoriented them.

X10. October 1998. Tacoma, Washington. About 300 starlings dropped out of tbe sky on this date. Neither poison ñor disease was the cause. The birds all suffered crushed chests and blood clots in hearts and lungs. Since starlings fly in tight formations, «orne speculated they had smashed into the. side of a large truck (?], or perhaps a wind gust had thrown them to earth violently. (R9, RIO)

Compare this even with X7, where decompression produeed similar injuries to birds in flight.

Xll. February 2005. Newcastle, Australia. If pizza can fall from the sky (GWF5- X16), why not plucked, frozen chickens. Two such cases heve been reportad from the same city in Australia. One even smashed roof tiles and wasn't discovered until the smell of decay gave it away! (Rll, R12)

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Rll, Anonymous; New York Post, Febru- ary 11, 2005. Cr. M. Piechota. (Xll) R12. O'Shea, Francis; "Fowl Play." Sydney Daily Telegraph, February 10, 2005. Cr. L.M. Nash. (Xll)

GWF14 Falls of Miscellaneous Living Animáis

Description. Falls oí living animáis other than Ihose üescribed in earlier sections. Included here are purported falls of shelliish, snaíls, snakes, lizards, and similar reptiles and amphibians. As with the other reported animal falls, the miscellaneous falls are generally concurrent with heavy rainfall. Very large numbers of individuáis may be involved. These falls usually < onsist of one species only. with no accompanying debris.

Background. Heavy precipítation may drive terrestrlal animáis out of their hiding places and, in other instances, stimulate population explosions or mass movements. Most bumans have little appreciation for the immense numbers of animáis living hidden around them.
Thus, when a storm drives these creatures abroad in great numbers, anomalous falls from the sky are claimed erroneously.

Data Evaluation. Most reports of animal falls recorded below are suspect because the animáis were not actually seen in ñight. The evidence for a "fall" ¡s therefore circumstantial. A few cases are rather convincing (XI, X2, XC, X7); and these generally irtvolve water- dwelling species. Composite rating: 2.

Anomaly Evaluation. The best cases, which inelude water-dwelling anlmals, yield readily to the usual wlurlwind-waterspout-tornado explanatíon. It is curíous though how shellfish, for example, are separated so cleanly from the sand in which they líve. The weakest cases concern rather large animáis, snakes, turtles, etc., and would require very strong winds to whisk them aluft. The puzzling aspeets here are minor, and a composite rating of 3 is all that is justified. Rating: 3.

Pos si ble Explariations. The familiar trio: whirlwinds, waterspouts, and tornados.
Similar and Related Phenomena. AJI other animal falls in CW'F. See also "population explosions" in Bl, BR, etc.

Lxamples of Falls of Miscellaneous Living Animáis [*1]

XI. June 8, 1861. Salem, Iowa."'Onthe night of June 8, 1881, there was a heavy rain-fall, and on the morning of the 9th, the ground was covered, in places, with some- thing that looked like blood. I found that they were living creatures, and with aspoon took up a pint of the muddy water containLng them.' Upon examining the sample received,
1 found it to be swarming with Cyclups quad- ricornis. or what 1 take to be that species. The only thing peculiar about them, is, that the body is full of bright red corpuscles, which accounts for their impartíng a red ap- pearance to the water containing them..., While it might not be considered remarkable that a few of these animáis should be found ín pc*ols of rain- water, 1 am puzzled to un- derstand how they carne here in such immense numbers, unless we suppose that they were distributed through the whole body of rain that fell, and were afterwards coriccn • trated by the draining away of surplus water. There were not less than five hundred in the sample of water sent me, of which aboutone- third were alive when received, after having been tightly corked for several davs. " fR8)

Cyclops quadricornis is a small crustacean.

X2, August 1894. Bath, England. "Durínga recent thunderstorm at Bath there fell manv thuusands of small jelly fish. and the pave— ments and roads were splattered with them. They were of about the size of a shllling. " (R16)

X3. No date given. Monastereen, Ireland.
A shower of shells. (Rl)

X4. August 9, 1834. United States. A fall of molluscs. (R18)

X5. 3835. Montpeller, France. A fall of Bulimus truncatus. a tvpe of mollusc.
(R18)

X6. June 6, 1869, Chester, Pennsylvania.
’ Mr. John Ford exhibited to the Conchologi- cai Section, Academy of Natural Sciences, Philadelphia, specimens of Gemina gemina, remarkable as having fallen, accompanied by rain, in a storm which occurred at Chester, Pennsylvania, on the afternoon oí June 6, 1869, The specimens were perfect, but very minute, measuring one-etghth Ineh in length by three- sLxteenths oí an ínch In bread th. Though most of the specimens which fell were broken, yet many perfect ones were

collected in vartous places, sheltered from the heavy rain which followed their descent.
A witness oí the storm, Mr. Y.S. Walter, editor of the Delaware County Republican, assured Mr. F. that he noticed the singular character of the storm at Lts very commen- cement, and, to use bis own words, "it seemed like a storm within a storm. " A very fine rain fell rapidly, veiled by the shells, which fell slower and with a whlrl- ing motion. Judging from the remains of animal malter attached to sume of the apeci- mens, together with the fresh appearance oí the epidermis, it is highly probable that many of them were living at the moment of transítion. This minute species resembles a quahaug shell, and is common on the sea- shore between tide marks. " (R5)

X7. August 9, 1892. Paderborn, Germany. "A yellowish cloud attracted the attention of several people, both from its colour andtbe rapidity of its motion, when suddenly itburst, a torrential rain fell with a rattling sound, and immediately afterwards the pavement was found to be covered with hundreds of mussels." The mussels were still alíveand were identífíed as Anodonta anatina L. (R13, R19)

X8. Summer 1821. Brístol, England. A sup- posed shower of periwinkles. A resident of the area thought it was just the annual pilgrimage of Helix virgata iooking for a mate. (R3)

X9. May 1851. Bradford, England. A heavy shower of snails, which might have been gathered by the bushel. (R2)

X10. 1885. Pembroke Dockyard, England. A thick shower of small snails fell during a downpour of rain over a space about 100 yards in diameter. (R9) Another observer beLieved the snails were there all the time and emerged from hidlng after the rain. (RIO)

Xll. 1886. England. "Having heard that a fall of shell snails had taken place a few miles from here, I visited the place and found from a man who lived on the spot, that about sp. ra. just as ii was nearly dark, what appeared to be a very black thunder cloud rose from the west, and he went in for shelter. Nexi mor- ning, on going to work, the roads, fíeids and stone hedges were plentifully strewn with small living shell snails, the fall extending over about three acres of land, but beyond these hmits no shells were to be found."
(Rllt Once again, the snails were not seen to fall, and sudden emergence after a rain remains a viable explanation.

X12. July 3, 1886. Redruth, England. "After a rather prolonged períud of dry hot weather, a heavy thunder-shower fell onthe north side of the parish of Illogan, about three miles from Redruth, Cornwall, about 9 P. M. on Tbursday, July 8th, the wind be- ing N. N. W. On the following mornlng. a farmer resident in the district, going tohis work about 6 A. M., noticed that the roads and fields in the track over which the shower extended were strewed with small snails of a kind quite different to any previously observed in the district. They were then, he States, lying about in such numbers, that he could gather them together in handfuls. " (R12) Actual fall of snails not observed, as usual with this class of animal. (WRC)

X13. January 20, 1894. Nashville, Tennes- see. During unusually heavy rain, seven young men sheltering under art awning heard a splash and saw a living creature 5 feet from the pavement. Tbey captured a full-grown salamander (Amblystoma xiphias) 10 3/4 inches long. The animal was not actually seen to fall. (R17)

X14. December 1857. Montreal, Quebec, Ganada. A shower of livq lizards fell upen the sidewalks and streets. (R14, R21) X15. July 3, 1860. South Granville, New York. During a very heavy shower, observer hears sound at his feet, looksdown and finds a stunned snake. fie assumed it fell there during the rain. (R4)

X16. January 15, 1677. Memphis, Tennes- see. "Morning opened with light rain; 10.20 a. m. began to pour down in torrents, las- ting fiíteen minutes, wind SW; immediately after the reptiles were díscovered crawling on the sidewalks, in the ruad, gutters and yarda at Vanee Street, between Lauderdale and Goslee streets, two blocks; careful in- quiry was made to ascertain íf anyor.e had seen them descend, but without success; neither were they to be found in the cisterns, on roofs, or any elevations above theground; Vanee Street is comparatively new, has no pavements, gutters merely trenches; I heard of none being found eisewhere; when first they were a very dark brown, almost black; were very thick in some places, being tan- gled together like a mass of thread oryam." (R6) The foregoing is an on-the-spot re- port by a weather observer. The famous Memphis snake shower seems besl explained in terms of emergence after heavy rain.
But a later report in Scientifie American (R7) claims that thousandr of snakes 12-18 inches long fell after being "carried aloft by a hurricane."

X17. 1873. Minnesota. Shower oí unidenti- íied reptiles. (R18)
X18. May 11, 1894. Bovina, Mississippi. A gopher turtle, 6 by 8 inches, entirely eneased in ice, fell with the hail. (R15, R20, R22, R23, R18)

X19. During World War II. Salonika, Greece, along the Britísh position.
"...the sky rained small turtles, so thick that it was impos sible to move about without crushing two or three of them at every step." (R24)

X20. March 21, 1983. Dilborne, N. Staffordshire. England. Sea shells fell with heavy hail: "They extended for an area of about 50 by 20 metres and oeeur- red in thousands on lawns. flower beds, paths and even the road. Roy was kind enough to give me half-a-dozen speci- mens for Identification. They turned out to be small gastropods. almost certainly of marine origin." (R25)

Reeourse to field guides did not re- sult in posítive identification, so samples were sent to the Bristol Museum. The specimens turned out to be Dove Shells. family Columbellidae, genus Pyrene, whieh are normally inhabitants of the tropical seas. Their most likely origin was the Philippines!

It's a very selective whirlwind that can identify and pick up so many shells of the same species!

X21. June 19, 1984. Thirsk, North York- shire, England. After a heavy thunder- storm, a small area was covered with winkles (shellfish), some still alíve, and starfish. Thirsk is 45 kilometers from the sea! (R26, R28)

R28 gives the date as June 16.

X22. June 5, 1984. Brighton, England.
A large spider crab dropped out of a storm cloud in front of Julián Cowan.
The crab measured 25 ero across and had a 7-8- cm shell. It was dead and lacked two legs and one claw. The fall was followed almost immediately by wind- driven hailstones, (R24)

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GWF15 Fall of Giant Dust Partióles from Distant Sources

Description. The fall of giant dust partióles thousands of mijes from their place of origin. Established meteorológica] laws cannot account for the transportation of such large dust partióles íover 20 microns) for such great distances.

Data Evaluation. So far, we have only one pertinent scientific study that was published in a mainstream journal. Rating: 2.

Anomaly Evaluation. The particles' size and distance-of-travel suggest that there exist unrecognized ascending air currents and/or unsuspected aerial suspensión forces. Rating: 3.

Possible Explanation. Unidentiñed buoyant air currents.

Similar and Related Phenomena. The long-distance transportation of pollen (GVVF3) leaves and hay (GWF6); seashelJs (GWF14),

Example

XI- March 1986. Wake lsland, Hawaii.
A dust cloud originating in China reached tliese islanda after traveling 6,000 miles ín 9 days. The fact that dust stirred up in the Asian deserts is some- times carried thousands of miles is not unusual. But the March 1986 cloud con- tained quartz particles of giant dimen- sions-----far too large to be explained by currently accepted meteorological laws describing dust transport.

More than 80% of the quartz granules measured more than 70 microns in din- meter. This is more than four times the caleulated máximum size of 16 microns for a cloud that has travelled 6,000 miles. Assuming a máximum starting altitude of S miles, the 70- micron partióles in the Chínese cloud should have remained suspended only a day or two instead of the 9 days observed. (Rl)

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GWH ANOMALIES AND CURIOSITIES OF HURRICANES, THUNDERSTORMS, AND REMARKABLE WINDS

Key to Phenomena

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GWH2 Hurricane Geographicaf Anomalías
GWH3 Polygonal Eye Walls in Some Hurricanes
GWH4 Hurricane interna) Fine Structure
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GWH14 Unknown Origin of Slow Atmospheric Oscillations GWH15 The Remarkably Long Wind-Wake of ihe Hawaiian Islands GWH16 Rock-Fall Air Blasts
GWH17 Curious Wind-Downburst Damage in Amazonia GWH18 Magnetic Recursors ot Large

GWHO Introduction

The two major categories of storms dealt with in this chapter are hurricanes and thunderstorms, as announced in the title. There is, in addition, a misceUaneous category including whole-atmosphere oscillations and curious local wind phenomena.

As seen on TV, hurricanes are ponderous, meandering, destructive storms. Despite such negative publicity, hurricanes also possess fascinating fine structure, unexplained infernal dynamics, and even unplumbed cyclicity.

Thunderstorms are generally thought to be local weatner phenomena. However, some cluster into truly giant storm systems hundreds of miles in dimensión.
These display complex electrical structure and even relate to the planet's carbón cycle. But even the simple "pop-up" thunderstorms seem to have the power to curdle milk!

Freak winds are legión—some are also anomalous. The wind blasts from giant rock falls and the lengthy wind wakes of the Hawaiian Islands are impressive but not paradigm-shattering. But then, there are those huge, piston-like downbursts that gouge out huge holes in the Amazonian forest but are so scarce elsewhere.

GWH1 Ozone in Hurricanes

Description, The smeli of ozone ur its instrumental detectiou at abnormally bigh levels during powerful hurricanes.

Data Evaluation. A single report of good quality has been uncovered. Rating: 3.
Anomaly Evaluation. Hurricanes are usually not accompanied by signifícant electrical aetivity, so the existence of a strong odor of ozone is perplexing. If not electrically gene- rated, where could the ozone origínate? Rating: 2.

Possjble Explanations. Hurricanes are powerful storms, and it ¡s possible tbat some diffuse electrical discharge occurs. Such discharges need not be detectable by eye and ear.

Similar and Related Phenoraena. The smeli of ozone and sulphur frequently attend sorae of the more concentrated storms, such as tornados and thunderstorms.

Examples of Hurricane Ozone

XI. September 21, 1938. Amhersl, Massa- chusetts. "During thehurricane un September 21, 1938, the smeli of ozone was strong during the latter pan of the storm. The peak of the storm was shortly after 6 P. M. (D. S. T.); the lowe&t barometer 28.41 (corrected) at Amherst, Mass., being at 6:05, and the highesl wind velocity, SO miles, at <3:17. During the heavy rain, ahout 6 to 6:30, the ozone was strong, and later, when the rain stopped, the- >>zone was so strong I was un- comfortable. Ai this time my watch said 7 o'dock. No odor of ozone was notíeed in the first part of the storm ñor was any noticeable in the house. My colleague in chemistry, in the Massachusetls State Cnllege, Dr. Walter S. Ritchie, independently repurts similar ob- servations. " vUl)

References

Rl. Peters, Charles A.; "Ozone in the '38 Hurricane," Science, 90:491, 1939. iXl)

GWH2 Hurricane Geographical Anomaiies

Description. Prior to 2004, the absence of any historical record of hurricanes ín the South Atlantic Ocean. This long record was broken in 2004, when a storm called Catarina, with hurricane characteristics, carne ashore in Brazil,

Data Evaluation. The pre-2004 absence of South Atlantic hurricanes was first noted in a popular book (Rl) but was quickly confirmed in the McGraw-Hül Encyclopedia of Science and Technology. Notice of the major features of hurricane Catarina appeared in Science journals and magazines. Rating: 1.

Anomaly Evaluation. The North Atlantic spawns many hurncanes and the Pacific, both nórth and south of the Equator, develops its typhoons. the equivalents of hurricanes. From the standpoint of symmetry, one would expect at least a few South Atlantic hurricanes during recorded history. For some reason. however. the meteorológica! conditions in the South Atlantic are not conducive to hurricane formation. Exactly why they are not is a debatable problem. The appearance of Catarina in 2004 is eíther itself an anomaly or is indicative climate changes we de* not yet understand. Rating- 3.

GWH2 HURRICANE ANOMALIES

Possibie Explanations. The "official" explanation for the dearth of hurricanes in the South Atlantic is that the waters are too coid and the wind distribution with altitude are not conducive to intense tropical storms. An appealing and, to many, a reasonable explanation for the anomaious appearance of Catarina is that a chínate change (global warming) is in progress. Some radical thinkers, however, contend that extraterrestrial infhiences (see GWS5) may actually influence where hurricanes and typhoons occur.

Similar and Related Phenomena. To our knowledge, the Indian Oeean does not spawn hurricane-like storms, although monsoons afflict the area.

Examples of Hurricane Geographical Anomalies

XI. General observations. "There is no record of a tropical cyclone of hurricane Lnten- sity ever having occurred In the South Atlantic Oeean." (RI)

X2. March 27, 2004. South Atlantic Oeean. The media largely Ignored the storm eaüed Catarina. After all, it was equivalent to only a Category- 1 hurricane and did not threaten North America. But Catarina was unique.

It swept ashore March 27, 2004---------- not in North America or the Caribbean bvit in Brazil's state of Santa Catarina, from which it derived its ñame. Catarina was the first hurricane ever recorded in the South Atlantic. Some see it as a porteril of the future and associate it with global warming.

The anornalousness of Catarina can be seen in the meteorológica! records. Many hurricanes ("typhoons" in the Pacific) plague the North Atlantic and North Pacific during their summers and autumns. The South Pacific sees an occasional typhoon in that hemisphere's summers and autumns. The South Atlantic, though, had been totally spared, for reasons uncertain, untii 2004.

Catarina is blamed upon a slightly warmer oeean surfaefe and an unusual eombination of meteorológica! features. Nevertheless, NASA's J. Halverson ss- serted that Catarina "looks like a hurricane, with strong winds, heavy rain, and a well-Btructured eye." (R3)

In a few yeara, we should be able to determine if Catarina was a freak occur- rence or the beginning of a trend.

References

RI. Helm, Thomas; "Anatomy of Hurricanes, " Hurricanes: Weather at Its Worst, New York, 1967, p. 16. (XI) (Cr. L. Gearhart) R2. Chin, Gilbert, ed.; "The First of Many?" Science, 309:1302, 2005. (X2) R3. Hecht, Jeff; "The Strange Tale of the Hurricane That Wasn't," New Sci- entist, p. 16, April, 2004. (X2)
R4. Anonymous; "Catarina's Shock Mes- sage." New Scientist, p. 10, Septem- ber 24, 2005. (X2)

GWH3 Polygonal Eye Walls in Some Hurricanes

Description. The polygonal geometry of some hurricane eye-walls and surTOunding rain banda.

Data Evaluation. The Science literature contains many supporting satellite photo- graphs and radar-data analyses. Rating: 1.

Anomaly Evaluation. At present, we have no consensus hypothesis as to how polygonal structures are forroed in hurricanes. Rating: 3.

Possible Explanation. The polygonal structures are interference patterns formed by the storm's internal gravity waves.

Similar and Related Phenomena. The occasional honeycomb appearance of flowing water (GHC9 in Earthquakes, Tides, etc.).

Entry

XI. General observations. It is widely believed thBt hurricane eye walls and surrounding rain bands are nicely round or sometimee a bit elliptical. At lenst, this is what we usually see on satellite p hotos of powerful storms displayed on TV! There are, however, numerous t-x- ceptions where the eye walls are poly- donal; i.e., square, hexagonal, etc.
These polygonal forms appear too often to be merely fortuitous As B.M. I.ewis and H.F. Hawkins relate» analyses of radar data confirm the geometries thet the satellite eyes see.

”It was noied from analysis of radar data obtained in hurricanes that both the spiral bands and the inner houndaries of the wall cloud were frequently com- posed of a series of straight-line seg- ments. Indeed, the eye of a strong hurricane is frequently polygonal rather than circular or elliptical. These festures may have a possible kineniatíe explanation based on interference among differing wavc numbers and frequencies oí interna) gravity waves." (Rl)

Reference

Rl. Lewis, B.M., and Hawkins, H.F.; "Polygonal Eye Walls and Rainbands in Hurricanes," American Meteorologi- cal Society, Bulletin, 63:1204. 1982.

GWH4 Hurrícane Internal Fine Structure

Description. Selective ground damage by hurricanes and radar-detectíon of tubular-wind internal structure. The latter is thought to be the cause of the former.

Data EvaJuation- Helevant post-hurricane surveys of ground damage and doppler- radar analysis of hurricane wind patterns have been reported in the Science literature. Rating- 1.

Anomaly EvaJuation. The origin of hurricane tubular fíne structure is unknown. Rating: 3.

Similar and Related Phenomena. Hypercanes as contributors to environmental catastrophes and biológica] extinctions (GWH5); tornado "pranks" (GWT7).

Entry

XI. General observations. Some hurricanes display internal fíne structure.
This fact is obvious when one views ground damage. Although a hurricane may span hundreds of miles, it sometimos leaves behind narrow swathes of damage ordy hundreds of meters long bordered by land that is comparatively untouched. What is there about hurricane:; that can account for such selectivity?

In searching for an explanation, J Wurroan und colleagues, from the Univer- sity of Oklahorna at Norman, perked a van equipped with doppler radar in the path of Hurrícane Fran (September 1996, in North Carolina).

"They detected tubes of wind, like tornadoes turned on their sides, each a few hundred metres across. One side Lof each tubel took fast moving wind from on high and spat it toward the ground. 'It blows right down to treetop level,' says Wurman. Areas near the down- draughts were blown over; everywhere else was relatively safe from the storm." (Rl)

The origin of these tubular wind structures is at present a mystery.

Reference

Rl. Seife, Charles; "Blown Away," New Scientist, p. 15, May 2, 1998. <XTj~

See illustration on p. 150.

GWH5 Hypercanes and Global Biological Extinctions

Description. Hypothetical hypercanes ("runaway hurricanes") as extenders of bolide impacts and/or volcanism as mechanisms of global biológica] extinctions.

Data EvaJuation. The hypercane is hypothetical, although Computer simulations confirm its possible efficacy in geographically extending the reach of catastrophic events.

Anomaly Evaluation. No anomaly is claimed here.

Similar and Related Phenomena. Anomalies associated with biológica] extinctions (ESB1 in Anomalies in Geology).

Entry

XI. General observations. Scientists are in fundamental dieagreement concerning the relative efficaeies of volcanism and giant bolide impacts in causing global biológica! extínctions. K.A. Emannuel et al add to the armories of each of tbese two catastropic phenomena the hypo- thesis of the "hypercane." Hypercanes are "...runaway hurricanes that are capable of Injecting massive amounts of water and aerosols into the middle and upper atmosphere, wnere they may have protound effects on atmospheric ehemis- try and radiative transfer. Hypercanes are theorized to occur vvhen the sea sur- face temperature exceeds a critica] íhreshold, which may occur when sea water is locally heated by bolide impact. shallow-sea volcanism, or posaibly, by overturning of superheated brine pools formed by underwater volcanic actívity. Simulations using a convectiun-resolving nonhydrostatic axisymmetrie model show that hypercanes can mdeed develop when the sea surface temperature is high. and that they injeet large amounts of mass into the stralosphere." (RI)

The water and aerosols in the atmo- sphere would be spread far beyond the localizad phenomena and foster global temperatura and Chemical effects ímpae- ting the entire planet's biosphere.

Wc must emphasize that the fundamental ariomaly here is not the hypothe- tieal hypercane. Rather, it is the possible inadequacy of ioi-alized bolide impacts and volcanic actívity to explain global biológica! extinctions.

The hypothetical hypercane is a mechanism for geographically extendíng the effects of a bolide impact and/or volcanic eruption. Although it has never been observed and may not be anomalous if it ever ıʙ created, we introduce the hypercane idea because of its possible importance and genetic connection to ordinary hurricanes.

Reference

Rl. Emannuel. Kerry A., et al; "Hypercanes: A Possible Link in Global Extinction Scenarios, Jourruü geophysical Research. 100:13,755, 1995. (Xlj

GWH6 Typhoon Cycles

Description. A 50-year periodicity in the landfalls of typhoons in the south- eastern Chínese provmce of Guangdong.

Data Evaluation. The basic data sources are semiofficial records kept locally in southeastern China. Where overlap with modern records occurs. there is con- sistency with the observations of instrumented stations. Rating: 2.

Anomaly Evaluation. The source of the 50-year periodicity is uncertain.

Rating: 2.

Possible Explanations. North Atlantic hurricanes seem loosely connectetí to the presence of El Niños" ín the Pacific as well as to large-scale, long-term temper- ture oᵉcillations in the Atlantic. Such statistical connections probably also exist in the Pacific.

Similar und Related Phenomena. The long-term variabüity in the frequency of North A'tlantic hurricanes; astronomical periodicities in other weather phenomena (GVVS1 i.

Entry»

XI. Statistíeal Analysie. Reliable, con- tinuous weather records covering an entire millennium are very rare. Siich a record has been elaimed for the Guang- dong Provinee in southeastern China.
The record is in the íorm of semiofficisl, local gazettes called "fang zhi". The general accuracy of recent gazettes has been confirmed by comparing them with modern intrument records. The gazettes cleerly distinguish typhoons that impacl the Provinee from other storms for the past millennium.
From 975 A.D. to date 12002], at least 571 typhoons have come ashore in Guangdong Provinee Analysis by K.
Liu, n geographer at Louisiana State University, point to a puzzling periodi- city -
"Guangdong Provjnce's fang zhi show that over the past 500 yenrs. ihere's been a 50-voar eyele in the frequeney oi typhoons there. That periodicity matches matches a long-term variation in atmo- spheric conditions in the northern Pacific Oceen región." (RI)
The origin of the 50-year eyele has not been positively identiñed. It seems unrelated to any obvious astronomical periodicity, although, as with North Atlantic hurricanes, there is probably a conneetion to El ñiños and ocean tempera- ture changos—themselves poorly under- stood.

Reference

RI. Anonymous; "Chínese Records Show Typhoon Cvcles," Science News, 162: 174, 2002. (XI)

GWH7 Unexplained Rapid Intensification of Some Hurricanes

Description. The explosive increase in intensity of some hurricanes.

Data Evaluation. Primary source: NOAA (National Oceanic and Atmospharic Admini- stration). Rating: 1.

Anomaly Evaluation. Rapid hurricane intensification is a poorly understood phenomenon, not a paradigm challenger. Rating: 3.

Possible Explanation. Energy jn the encircling rain bands is transferred to the eye wall, but the physics of this energy exchange is still under investigation.

Entry

X0. General observations. Hurricane forecasters have become more expert in predicting the paths and landfalls of North Atlantic storms. In eontrast, the turbulence and complex dynamies of hurricanes have stymiod the accurate pre- diction of changes ín B storm's intensity.
Particularly puzzling are the frequent rapid spin-ups of some hurricanes. In the space of just 24 hours a low-strength tropical itorm can expiode t<> a Category-
5 hurricane------the highest intensity eate- gory. A puzzling factor in such rapid spin-ups is the obsevation that such exploding storms do not seem to cxtract most of their additional energy from the warm ocean water beneath them, which is normally a hurricane's primary source of energy. Rather, the eye-walls seem to derive their increased energy from the energy stored in the svirrounding rain bands. [An apt analogy occurs when a spinning ice-skater suddenly pulís in his or her arms and thus dramatically Increases the spin-rate.] How similar fests might be aceomplíshed in u strengthening hurricane still puzzles meteorologists.
(RI)

XI. Oeiober ?ti05. North Atlantic Ocean.

ln just one day, Hurricane Wilma transforme*] herself from n tropical storm into the most powerful Atlantic storm un record. (A Categorv-5 hurricane, of course.) (Ri)

X2. September 2005. North Atlantic Oeean. Modest Hurricane Rita spins up to Category-5 in just 8 hours. (XI)

Reference

RI. Schrope, Mark; "Winds of Change, Nature. 438:21. 2005. (X0-X2)

GWH8 Unexpected Geoqraohical and Electric-Charqe Organization of Large-Scale Electrical Storms

Description. The unexpectedly complex physical and eléctrica! organization of massive electrical storms.

Data Evaluation. The crucial data come from satellite observations and ground- based magnetic lightning-detectors. Results have been published in mainstream **Science** journals and magazines. Rating: **1.**

Artomaly Evaluation. Neither the large-scale clustering of thunderstorms ñor their electric-cbarge distrjbution are well-understood at present. Rating: 3.

Possible Explanation. An (unconvincing) appeal has been made to thc- wind dis- tribution in large storms.

Similar and Related Phenomena. Lightning superbolts (GLL17); cyclic flashing of lightning (GLL18); dual lightning discharges (GLL19); the bipolar nature of large-scale electrical storms (GLL28, actually a rerendering of X2 belowi. AU of the foregoing seetions are to be found in our catalog volume Remarkable Luminous Phenomena in Nature).

Entries

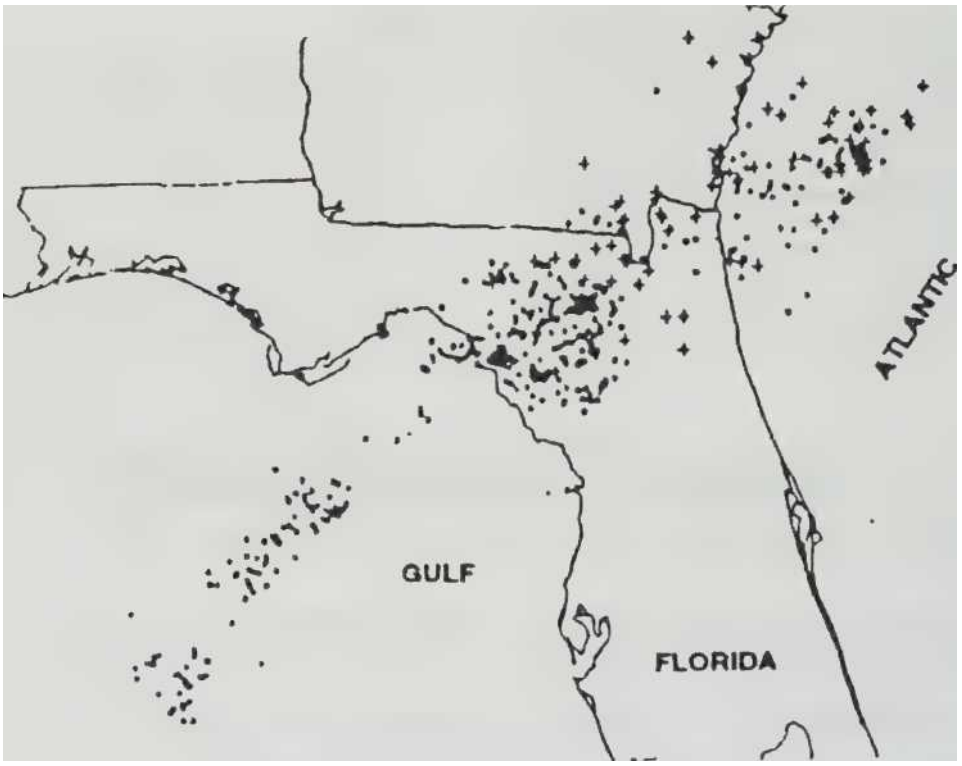
X0. Introduction. Hot summers always bring localized, "pop-up" thunderstorms. Not so routine are giant electrical storms that may span hundreds of miles. These **massive** metoorological formations are ful! of surprises in terms of their large- scale physicsl organization and bipolar electrical structure.

XI. Giant thunderstorm clustering. Con-ventional wisdom has it that thunderstorms are small-scale phenomena 50-100 miles across. However, J.M. Fritsch and R.A Maddox of NOAA have announced that satellite photos show a radically differpm situation.

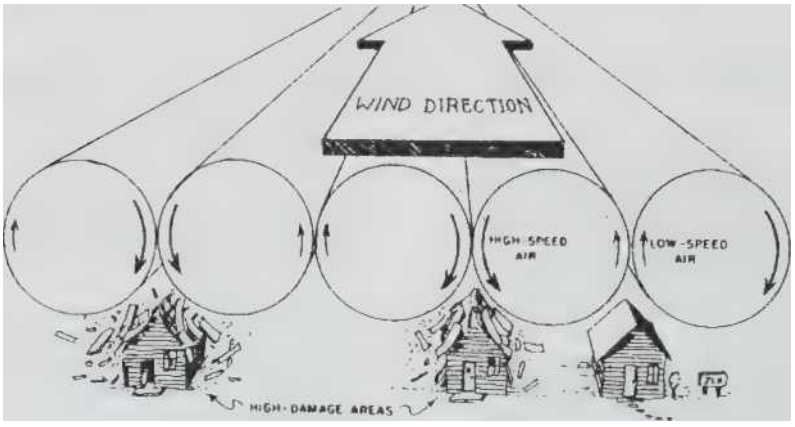
The more violent thunderstorniB are often organized into roughly circular clusters that may span 1000 miles. Pre- viously. all thunderstrn ms were eon- sidered local convectiva storms that were regulated by upper air pntterns. This view must now be changed because the newly recognized giant thunderstorm clusters setually modífy planetary upper air flow. (RI)

X2. Bipolar nature of large electrical storms. Ground-based observen- see only *n* few of the anvil shaped clouda that comprise a giant electrical storm. The entire storm may stretch tor hundreds of kilometers— and it i* not a simple structure.

The latest surprise is that al] large electrical storms are bipolar; that is, the rare positive lightning strokea are concentrated ni the northeast end of



Februaiy 22. 1987 Lightning distribution 8:00-9:00 P. ***Al. in ti rnassíve*** *thuniierstorm systcm aero****ss Florida. The plus*** *signs, designaliny posítive strokes. are concen-trated in the* ***northeast,*** *inúicating the storm svstem's* ***bipolar nature.*** *(X2)*



Horizontal wind tubes observad by radar dunng llurricane Frnn September 1 f)9fí, North Carolina. The tubes were nbout 100 meters in díameter and as Ico' as treetop level. i X I)*

the storm complex, while the negative strokes are everywhere else ajong a northeast-southwest line This bipolar structure persists for several hours, and it has been found in all North American storms analyzed so far. This insight into the structure of large elec- trical storms was provided by magnetic lightning detectors that have now been inptalled over nearly 75(1 of the United States.

The positivo lightning strokes are of longer duration and more liable to start fires than the common negative strokes. But why are thev concentrated at one end of the storm complex? R. Orville ventares that in *a* big mesoscale electri-cat storm. the prevailing winds blow the positively charged upper portions of the ciouds to the northeast, thus establish- ing bipolaritv. (R2)

References

RI. Bardwell, Steven; "Satellite Data Show New Class of Thunderstorms," Fusión Magazine, p. 50, September 1981. (XI)

R2. Orville, Richard E., et al; "Bipolar Patterns Revealed by Lightning Loea- tions in Mesoscale Storm Systems," Geophvsical Research Letters, 14:129, 1988. (X2)

GWH9 Hot-Air Blasts in Intense Electrical Storms

Description. Hot-air blasts experíenced during intense eléctrica] storms by individuáis and vegetation.

Data Evaluation. Testimony from individuáis and post-storm surveys of damage to crops and other vegetation. In the science literat-ure, we have only allusions to human experiences. A newspaper account provides graphic effects on crops and other vegetation. Based on our literature searching. the case for this claimed phenomenon is rather weak. Rating: 3.

Anomaly Evaluation. If electrical heatíng of the aír is assumed (rather than aerodynamic heating), the formation and propagaron of hot-air bursts are not well-understood. This is particularly so when broad areas of vegetation are affected (X2). Rating: 3.

Possible Explanation. Lightning releases considerable thermal energy and winds in storms could conceivably transport heated masses of air to spots well away from the lightning strike points.

Similar and Related Phenomena. Hot-air blasts associated with lightning (GLL12. which ineludes XI below); tornado burning and dehydration (GWT2).

Entries

X0. Introduction- Claíms have been made that bursts of intense heat have occa- sionally been experíenced during thunder- storms. We have collected sume general observations and one specific example.
This claimed phenomenon should be compared with the burning and dehydration effects reports in some tornados (GWT2).

XI. General observations. E.W. Grew suggests that lwo rare classes of meteoro-logical observations may be creatPd by the intense electroetatic accelerating forceB present in lightning channels.

The first class of observations c«>n- sists of blasts of hot oir nuted some distance from violent lightning strikes but seetningly associated with the dls- charges. Second, some superhailstones (hydrometeors. GWF1) also seero tu be correlated with violent lightning. The phvsical mechanism i'or thr- ronccTjtration and propulsión of rnatter JS the elet'ro- stntic forcé naturally present in lightning

riiseharge channels; it functions much the same as the particle accelerators in the physics lab. (RI)

The observations of hot air blasts and superhailstones collected by Crew to supporl his theory are indeed sug- gestive, but more are needed.

X2. June 1900. Kopperl, Texas. Thunder- clouds and lightning gove way to winds in excess of 75 mph, with temperatures of up to 140°F. Surveying the storm datnage later:

"Aside from the expected remoins of a severe wind storm—uprooted trees, snapped telephone poles. roof dsmage
and banged-up boats docked lakeside----------
the area had the ironic appearance nf having been stung by a June freeze,
Tree leaves, shrubs, hanging plants and crope were curled and wilted, as if frost-bítten. Cncut Johnson grass was dried and ready to bale, although the hay normally reduíred two »>r three days of drying time after being eut. Perhaps the moet etartling remaíns of the storm was in what had been the cotton patch at Pete and Inez Burns' farm. The cotton was about knee high and a 'luscious crop' the day before, according to the couple. The next morníng all that was left were carbonized stalks peeping out of the ground. The coro fared little better."
(R 2)

References

RI. Crew, E.W,; "Meteorological Flying Objeets," Roy al Astronomical Society, Quarterly Journal, 21:216, 1980. (XI) R2. Glaze, Dean; "Kopperi's Cióse En- counter with Satan's Storm," Meridian (Texas) Tribune, May 12, 1983. Cr.
J. Mohn. (X2>

GWH10 Thunderstorm Serial-Triggering of Other Thunderstorms

Deseription, The triggering of new thunderstorms by those that are fading away. A west-to-east trail of thunderstorm death and birth has been observed.

Data Evaluation. This triggering effect is seen ín a massive collection of weather- radar data. Our reference is from a Science magazine. Presumably more detailed Information exists in unexamined specialist journals. Rating: 2.

Anomaly Evaluation. The details of the ''triggering'' process is poorly understood.
How are the conditions conducive to lightning discharges carried for many miles?
Rating: 3.

Possible Explariation. See XI below. Atmospheric waves may somehow be involved.

Similar and Related Phenomena. Dual lightning discharges (GLL19); cyclic flashing of lighinng tr.LL18); correlation of lightning with cosmic rays (GLL16) . All of these cross references are to be found in our catalog Remarkable Luminous Phenomena.

Entry

XI. Radar observations. Thunderstorms do not always fade away to nothingness. Apparently some dying thunderstorms can, jn soroe undetermined way, trigger new storms some distance away, in effect extending thetr lives.
R. Carbone et al. at the National Center for Atmospheric Research in Boulder, analyzed 50,000 radar images of thunderstorms ereurring between 1997 and 2000. A surprising pattern emerged.

"'As systems die, they cause the birth of new groups of thunderstorms in a verv systematic way.' he IC-nrbone] savs. One storm trlggers another and so

on, creating ripples of rain that move west to east from the eastern edge of the Hockies to the Appalschian ¡Vlouri- tains." (RI)

Carbono speculates that the rippling progress of thunderstorms is related to "enormous" atmospheric waves.

Reference

RI, Svitil, Kathy A.; "Roliing Thunder." Disoover, 23:13, October 2002. (XI)

GWH11 Lightning and the Plant-Voladle Discrepancy

Description. The possible role of lightning in the loss of the bitumen from plant volátiles through geological time.

Data Evaluation. The three natural phenotnena described below (XI) are well- known and supported by the scienee literature. In this regard, see the Biblio- graphy in RI. Ratíng: 1.

Anomaly Evaluation. The unknown fate of bitumen derived from plant volátiles in the global carbón evcle roust be considered an important anomaly. Rating: 2.

Possible Explanation. See XI below.

Similar and Related Phenomena. The geographical preferences of lightning (GLL13) in our catalog Remarkable Luminous Phenomena) .

Entry *1

XI. General observations. This catalog entry associates three widelv recognized natural phenomena with global thunder- storm activity and, as a consequence, expíalos the bitumen discrepancy now outlined.

(1) The loss of bitumen from plant volátiles. "Per year approximately 1.75 x 10** tons of volalile matter is formed, of which most should return to earth as bitumen if the above condensation mechanism Is correet This would have resulted in 10^{17} tons of nonreactive bi- tuminous material in the earth's crust during the 5 *y* 10® years that land plants have existed on earth. This is severa) orders of magnitude more than what is actually known to exist. There- fore mechanisns must exist which destroy the major portion of this organic material." (RI)

(2) An unappreciated source of thun- derstonn energy. "Both tornadoes and the lightning in thunderstorms depend on the instantaneous release oí very large quantities of energy, tnaking it unlikely that they are controllcd by local heat and wind supplies. In both cases, stored Chemical energy in the torrn of t ondensed volatile organic matter released by vpge- tation can account for this energy." (RI)

(3) The geographie dístributiori of thunderstorms. "Since thunderstorms develop predominately in areas where volatile organic matter occurs in the air and their frequeney is about propertional to the organic matter released, it seenis attractive to trace the clectric charge formation in the thunderstorm to organic matter.[71] (RI)

A possible Rnd reasonable conclusión has thunderstorms comsuming plant volátiles as fuel and thereby greatly re- ducing the amount of bitumen returning to the earth from the atmosphere.

Reference

RI. Went, F.W.; "Thunderstorms as Related to Organic Matter in the Atmosphere," National Acadeiny oí Sciences, Proceedings, 48:309, 1962. (XIT

GWH12 The Supposed Sudden Souring of Milk during Thunderstorms

Description. The honry assertion that exposed milk wil) quickly sour during a thunderstorm.

Data Evaluation. So íar, we have found only anecdotes of the phenomenon in a **Science magazine.** These **are** rather **convincing** but, lacking **anv seientiñe** tests, we cannot say the phenomenon ls well-established. However, more literature searching may be more illuminating. Rating: 2.

Anoraaly Evaluation. Home separators and creameríes routinely sepárate the fatty constituents of whole milk to produce creara, low-fat milk, etc, Centrifugation of milk has been the common technique for many years. The question is whether the natural fortes in a thunderstorm (electromagnetic and acoustical) can also somehow sepárate the fatty globules from the aqueous component of milk. It scems quite certain that they can if we choose to rely on anecdotes. Here, however, we insist upon a quantitative exploration of the phenomenon. V.'e have yet to find such technical confirmation. Rating: 3.

Possible Explanations. See above discussion.

Simular and Related Phenomena. Home cream separators. industrial emulsión separation.

Entries

XO. Introduction. In 1996 a reader of New Sclentlst resurrected ttie ancient elaim that thunderstorms will cause ex- posed milk to sour quickly. At first glance, this has the flavor of en oíd wive's tale. But modern informal tests are so convincing that the elaimed phenomenon should be investígated more thoroughly. In fact, ít would not sur- prise to learn that tliis matter has long ago been resolved in literature we have not yet searched.

We begin with two examples.

XI. Summer 1994. United Kingdorn. "One evening in the summer of 1994, i re- tired to bed with a glass of milk. During the night there was a tremendous thunderstorm with plenty of lightning and the following morning the remainder of the milk had curdled into a solid mass. (Rl)

X2. 1996. Amersham, Bucks, United Kingdorn. V. Dawson wrote New Scien- tist as follows on this matter: "1 ele- cided to test it myself and deliberately left a covered glass of Jresh, pasteurized milk taken strRight from the frige on the back doorstep during a thunderstorm. Within 15 minutes the milk in the glass had separated into a clear whey-iike layer overlaying a layer of curd, Tasting the remixed milk confirmed that it had not turned sour, only curdled. (Rl)

X3. Possible explanations. P, Wilson, responding to the New Scientist anee- dotes, suggested that the strong electric fields of thunderstorms might polarize emulsions and sepárate them into fatty and aqueous components. (R2)

The spectrum of intense low-frequency sounds during n thunderstorm seems a more liKely separotor of fatty globules.

References

Rl. Dawson, Val; "Sour Cream." New Scientist, p. 93, November 30. T996. (XI, X2)
R2. Wilson, P.; "Sour Creara," New Scientist. r* 89, Februnrv 15^ T997. (X3)

GWH13 Giant Windstorms in the Upper Atmosphere

Description. The existence in the earth's mesosphere (30-60 miles altitude) of continent-size windstorms.

Data Evaluation. The data come from the Upper Atmosphere Research Satellite. The Sourcebook Project ñles contain only an article from the New York Times bearing on this subject. Without doubt, technical reports can be found in the Science literature. But we have not yet assimilated them. Rating: 2.

Anomaly Evaluation. Unquestionably, meteorologists were surprised at the size of the mesosphere windstorms. but surprise is not equivalen! to anomalousness. The rationale for the formation of the mesospheric storms seems sound (XI below); so these giant storms must be classified as only euriosities. Rating: 3.

Possible Explanation. See XI below.

Similar and Related Phenomena. The gross expansión of the sizes of weather bal- loons as they aseend into the low pressures of the stratosphere.

Entry

X0. Introduction. The mesosphere is a poorly studied layer of the earth's atmosphere residing between 30 and 60 miles altitude. It is too high for study by aircraft and balloons and too low for most research sateliites. To explore this thin-aired, relatively unknown región, NASA, in 1991, launehed from a Space Shuttle the Upper Atmosphere Research Satellite. This spacecraft corried ten instrumenta ínto the mysterious mesosphere.

XI. General observations. Meteorologists were greatlv surprised when the new satellite mapped out vía its Instruments eontinent-size wind storms. The biggest of these stretched from Western Australia, covered Africa, and terminated half-way across the Atlantic Ocean.

The postulated source of this lBrge- scale weather phenomenon, marked by 200 miles-per-hour winds, lies in the lower atmosphere. Low-altitude weather generales small wind waves that expand in size as they aseend through the thin air of the stratosphere. When they enter the near-vaeuum of the mesosphere, th€:y expand even more and become the mon-strous windstorms ericountered by the Upper Atmosphere Research Satellite.
(Rl)

Reference

Rl. Anonymous; "Huge Windstorms Seen in Upper Atmosphere." New York Times, December 17, 1991. Cr. P Gunkel. (XI)

GWH14 Unknown Origin of Slow Atmospheric Oscillations

Description. The unexplained presence along a path 10° noríh and south of the Equator of an atmospheric oscillation with a period of 40-50 days.

Data Evaluatíon. The phenomenon can be followed from satellites and ground-based meteorológica! instrumenís. It is well-established Ln the Science journals. Rating: 1.

Anotnaly Evaluation, The causeCs) of this oscillation with its relatively stable period has no consensus explanation. Rating: 3.

Possible Explanations. As with the El Niños, variations of sea-surface temperature. An undefined connection to the the atmospheric heat engine earrying energy away from the tropics.

Similar and Related Phenomena. El Niños (see our Science Frontiers Ii. pp. 46. 54-55, 211).

Entry

X0. Introduction. The large-scale atmospheric oscillations known as El Niños have been recognized by meteorologists for decades. Associated with warmings of Pacific Ocean waters, El Niños generate abnormal weather globally every 3-8 years.

Wesker thon the El Niños but much more regular are some puzzling, 40-50- day atmospheric oscillations. These phenomena are not tied to ocean warmings like the El Niños. Otherwise, they resemble the El Niños and also heve their global reach.

Xl. General observations. "From a satellite's perch, the new phenomenon appears as a wave of cloudiness that first develops every 40 to 50 days in the Iridian Ocean, intensifies as it sweeps eastward into the Pacific at up to 30 kilometers per hour, and peters out ín the eastern Pacific. Other meteoro- logical observations can follow the dis- turbance through the tropics around the globe." (RI)

This "high-frequency" phenomenon (compared to El Niño) was discovered serendipltouslv in 1971 by R. Madden and P. Julián of the National Center for Atmospheric Research at Boulder. Al- though it is a fairly robust phenomenon, itв presence had previously been all but obliterated by meteorologists' use of monthly averagcs in their analyses.

The 40-50-day oscillation is essentially tropical-----just 1(1° north and south of the Equatoi------but its effects are felt as far away as the poles.

For example, 15 kilometers above Cantón Jsland in the central Pacific, the oscillation can alter the winds by 9u kilometers per hour, even reversing the norma] flow, It may also trigger or re- tard the onset of the much more power- ful El Niño.

"Still, what makes it tick remeins mysterious. It beors an enticing resem- blance to El Niño events. Both involve modulntion of the intensity and an eastward shift of the center of convection in the Pacific, and both seem to form similar teleconnections to mid-latitudes." **(R I)**

Reference

Rl. Kerr, Richard A.; "Slow Atmospheric Oscillations Confirmad," Science. 225 1010, 1984. (Xl)

GWH15 The Remarkably Long Wind-Wake of the Hawaiian Islands

Descnption. The 3 ,ÚUfl-kilometer-long wind-wake of the Hawaiian Islands—the longest on Planet Earth.

Data Evaluation. The wind-wake of the Hawaiian Islands has been observed íor decades by high-flying aircraft and, more recently, by sateililes. Rating: 1.

Anomaly Evaluation. None claimed. Nevertheless, an interesting natural phenomenon.

Possible Explanations. None needed. But, it should be added that the steady trade winds and high Hawaiian movintain peaks give Hawaii a large advantage in this compe tition.

Similar and Related Phenomena. Manv oceanic islands créate long wina-wakes. They just cannot compete with that of the Hawaiian Islands.

Entry

Xfl. Introduction. Some phenomena may not be anomalous but are stíll interesting enough to inelude in this Catalog. Such is the unexpectedly long wind-wake of the Hawaiian Islands.

XI. Frequent occurrence. From aircraft and satellites, one can see strong con- trasts in the roughness of the otean surface in the lee of the ídyllie Hawaiian Islands with their volcanic peaks that poke over 10,000 feet into the Pacific alrstreams. These long streaks on the ocean surface are called "wind wakes."

The wind wake leeward the Hawaii is epectacular. These islands are swept by steady northeast trade windᶜ. Mauna Kea (4201 meters), Mauna Loa (4201 rneters), and other Hawaiian peaks penétrate high above trade inversión. Togelher they create a visible wind wake some 3.00Ü kilometers long to the west----------many times greeter than any other island wind wakes that can be seen on the planet.

The effeets of these soaring peaks are more than visual. Their wind wake drives en eastward ocean ctirrent that, in turn, drsws warm wnter away from the Asían coast 8,000 kilometers distant from Hawaii. Thus, a few mid-Paciíic island inountains affect the climate of a distant continent a fifth of the way around the globe! (RI)

Reference

RI. Xie, Shang-Ping, et al; ʳFar- Reachíng Effeets of the Hawaiian Islands on the Pacific Ocean-Atmo- sphere System," Science. 292:2057, 2001. (XI)

GWH16 Rock-Fall Air Blasts

Description. The unexpectedly víolent blasts of air that follow large rock falls-

Data Evaluation. Many eyewitness accounta of a specific rock-fall. These were published in a mainstream geology journal. Ratingr i.

Anomaly Evaluation. No anomaly claimed here. This entry is included for the remarkable magnitude of the event and its consequences. Rating: 4.

Similar and Related Phenomena. Air blasts preceding snow avalanehes. Air blasts accompanving large explosions, especially detonations of nuclear weapons.

Entry

XO Introduction. It is well known that snow avalanches act Iike pistons and push blasts of air at hurrieane speeds nhead of the deluges of snow. In 1996 an unusual rock fall at Yosemite created o similar air blast with severe conse- quences. The mechamos of this phenc- rrenon are no mystery. This entry is added solely for its unusual character and possible general interest.

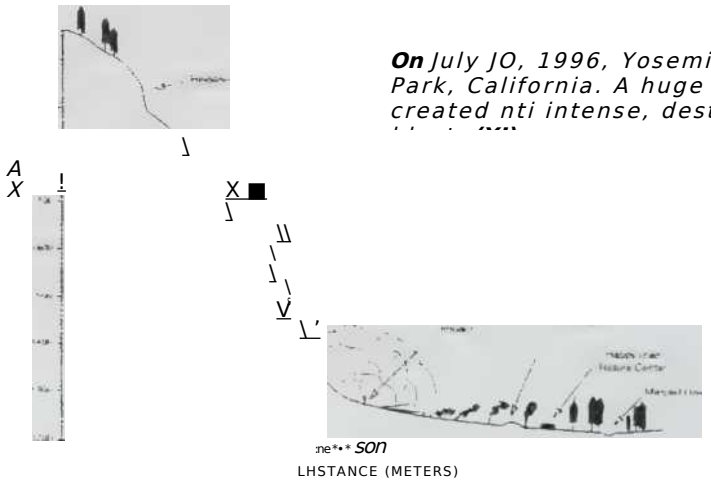
XI. July 10, 1996. Yosemite National Park, California. This remarkable event produced seisrnic waves, which jostled seismographs at Berkeley and Reno over 200 kilometers distant.

Actually, therr were two rock falls 14 seconds apart. The "rocks" fell from a 665-meter cliff at Happy ¡síes in the eastern part of Yosemite Valley. No pebbles these, with volumes of 23,000 and 38,000 cubic meters.

"Although the impact area of the rock falls was not particularly large, the falls generated an air blast and an abrasive sondy cioud that devastated a larger area downslope of the impact sites toward the Happy Isles Nature Center. Immediately downslope of the impaets, the air blast had velocities exceeding 110 m/s [about 245 mph 1 and toppled or snapped about 1,000 trees. Even at dis- tances ot 0,5 km from impact, wind velociies snapped or toppled large trees, causíng une fntality and several serious injuries beyond the Happy Isles Nature Center, A dense sandy cioud trailed the air blast and abraded fallen trunks and trees left standing." (Rl)

Reference

Rl. Wieczorek, (Jerald F. et al; "Unusual July 10, 1996, Rock Fall at Happy Isles, Yosemite National Park," Geological Society of America, Bui- letín, 112:75, 2000. (XI)



***On** July JO, 1996, Yosemite National Park, California. A huge rock fall created nti intense, destrvetive nir*

LHSTANCE (METERS)

GWH17 Curious Wind-Downburst Damage in Amazonia

Description. The presence in Amazonia (and probably elsewhere) of isolated arcas, each several square miles in extern, where trees and other vegetation have been devastated, presumably by violent downbursts of wind. The blasted areas appear like miniature Tunguska Events.

Data Evaluation. The forest scars show up on satellite photos, but ground-truth data are skimpy in our collection. We have no record of eye-witness accounts of the postulated downbursts. Our basic Information comes from U.S. newspapers. Rating: 3.

Anomaly Evaluation. Whatever flattened such large traets of Amazon forest are assumed to have been intense, unrecognized natural phenomena. These remarkable events have been blamed on wind downbursts, which are tentatively associated with distant thunderstorms. This hypothesis seems questionable. Rating: 2.

Possible Explanations. See above, to which we add the possibility of Tunguska- like impaets, due possibly to hydrometeors (GWF1) or above-ground meteor detonations.

Similar and Related Phenomena. Hydrometeor impaets (GWF1); other mysterious craters and analogous terrestrial damage in South America (R3); the Tunguska Event (ETC3-X1 in our catalog Carolina Bays, Mima Mounds.. .) .

Entry * 10

XO. Introduction. The Amazon región seems \o be receiving more than its share of natural calamities. We have. for example, not only meteor-devastnted swaths of destruetion (113) but the strange "cráter" reported in X2 below, which may or may not be related to the subject phenomenon laid out next ln XI.

XI. Irregular occurrence. "Scientists atudying weather patterns in the Amazon Basiñ have detected extremely powerful, sudden bureta of wind over the rain- forest, The winds, which appear to be associated with thunderstorms in the northwest part of Brazil, blow downward with tremendous forcé. Satellite photos indícate thnt a single episode demolíshed

10 square miles of junglc in only 20 minutes." (Rl) ,

To our kuowledge these hypothesized downbursts have never been describen by observers on the ground. Fttrlher- more, the association with very distant thunderstorms is questionable. Given these susper-t conditions and also the presence of several additional craters of mysterious origin elsewhere in South America, we add for the purpose of comparison the following event. (R3)

X2. 1995. Northeastern Brazil. Could the hypothesized wind-damaged areas the Amazon Basin (XI), be vnstoaü craters left by impaets *of* hydrometers? Although the cormection of the following event to those of Xl is tenuous, it must al least be mentioned here for suspicious minds to consider.

"Scientists on Bruzil's northeastern State of Piaui are bnffled by a cráter thnt was punched inte the tropical rain forest shortly afler wilnesses reported Beeing a bright light streak across the sky. Researchers are uncertain whether the cráter, 16 feet wide and 32 feet deep, was left bv a meteorito or a piece of a comet. Physicist Paulo Frota of the University of Piaui believes it was caused by a block uf ice from a comet because the surrounding vegetation is not burned and the crater's rim is not raised." (R2)

References

Rl. Anonymous; 1NFO Journal, #74-39, Winter 199b. 1NFO = International Fortenn Organization. Source eited: Alexandria (Virginia) Journal. Jun*- 30, 1995. (XI)

R 2 . Anonymous; "Cráter Mystery," Anchorage Daily News, October 1. 1955. Cr. .1, & L. Nicholsom via L. Farish. (X 2

R3. Corliss, William R.; Sciencp Fron- tiers II, Cien Arm, 2004, p. 177 fX2)~

GWH18 Magnetic Precursors of Large Storms

Description. Significará disturbances of the geomagnetic field several days before the arrival of severe storms. Direct causal connections between a brewing storm and distant magnetometers, if they exist at all, are obscure.

Data Evaluation. The successful forecasting of some large storms by magnetometer perturbations despite contrary forecasts by eonventíonal meteorological methods and s.atellite observations, We rely here upon a brief discussion in a respectad Science magazine. Rating: 2.

Anomalv Evaluation. It is difficult to identify any direct causal connection between a distant embryonic storm and local geomagnetic fields. Rating; 2,

Possible Explanation. Solar storms, which do jostle terrestrial magnetometers. may affect storminess, too, through the solar wind and cosmic rays. ln this, we see a potential indírect connection that may explain the subject phenomenon.

Similar and Related Phenomena. Infrasound from distant severe storms (GS11 in our catalog Earthquakes, Tides_____),

Entry

XI, January 22, 1986, Fredrícksburg. Virginia. A magnetometer at the Fred- ricksburg Magnetic Observatnry recorded n sudden jump (of 45 gammas) in the earth's horizontal magnetic-field com- ponent. Alerted by this. G. Wolin, at the Lamont-Doherty Geológica] Observa- tory, immediately predicted t ti at a major snowstorm or flooding ralns would hit northeastern States within six days.
Wolin contacted the weather people in the región, but they discounted the pre- diction because satellite pictures and eonventíonal westher indicators implied nothing of the surt.

A three-day storm began on January 25. depositíng 3 feet of snow in northern New F.ngland and 4 inches of rain along the coast from Washington to Boston. Wolin has had similar successea. without even lookíng at a weather mapí

Obviously Wolin's forecasting teeh- niques are not yet part of the Weather Bureau's arsenal. This is not too sur- prising because even Wolin does not understand why major storms should be preceded by several days by nervous magnetometers. He talks in a tentative way about solar storms, which do affect terrestrial magnetism, dumping energy into the oceans snd thence into the atmospherc, But this is mainly specu- lation.

Historically we know that long-term changes in the earth's magnetic ñeld ere linked to global temperature levels; but here, too, cause and effect are not obvious. (Rl)

Reference

Rl. Gribbin, John; "Magnetic Poínters to Storm y Weather," New Scientist. p. 70, Deeember 25, 1988. (XI)

GWI ANOMALOUSINCENDIARY PHENOMENA

Key to Phenomena

GWIO Introduction
GWI1 Cyclic Natural Fires ir» Brushand Forest
GWI2 Spontaneous Natural Fires
GWI3 Great Natural Conflagrationsín North America in Human

GWIO Introduction

Later in this voluroe, Chapter GWS, we describe severa] purported. cause-and- effeet connections between terrestrial weather and astronomical phenomena.
The sun. as we aU know. sets our docks and determines our seasons. Desides the sun's annual mfluence on weather, the 11-year sunspot eycle also affects rainfall, dry seasons, and storminess. Since dry se«sons provide fuel íor fires and storms wxth lightning add ignition sources, we would expect to see both annual and 11-year signáis in natural brush and forest fires. Actually, there are much longer, more enigmatic cycles of terrestrial conflagrations, the longest reaching far down the geolugical column. These are of ínterest to anomalists.

We find that solar storms also provide terrestrial tire-ignition possibilities.
The fluctuations in the geomagnetic tield caused by intense solar storms can generate strong eléctrica) currents in natural and human-made conductors. Sume of these electrical dísturbances can ignite fires.

Down the 4.6-bíllion-year history of our planet there have been many great con- flagrations. These are evidenced by layers of soot in the geological column. (See ESC in Anomalies in Geology.) Within human times, there have also been natural conflagrations worthy of cataloging. In this chapter, we choose the largely for- gotten great ñrestorm of 1871 that set North Central North America, including Chicago, ablaze; and in addition generated somc impressive anomalies.

GWI1 Cyclic Natural Fires ¡n Brush and Forest

Description. The cyclic appearance of natural wildfíres, specifically great forest and brush fires.

Data Evaíuation. Wildfíres, particularly forest fires, are customarily attributed to careless human aetivities and lightning. But the data also rev>‘al periodicitíes that can be scientífically attributed (via cause-and-effect) to phenomena associated with solar activity. Mainstream Science has paid little attention to such long- period cyelícities in natural incendiary events. Rating: 3.

Anomaly Evaíuation. That Nature hersetf is a cyclic arsonist contradicts popular belief-----except perhaps for the usual annual ignitions by summer thunderstorms. ludicstions that Nature is also behind some long-period fire cycles, therefore, is mildly anomalous. In particular, the proposed dire influences of Coronal Mass Ejections (CMEs) by the sun on natural, terrestrial ñre cycles remain controversia!. Rating: 3.

Similar and Related Phenomena. Spontaneous, ostensibly inexplicable fires of natural origin (GWI2); colossal, wide-area natural eonflagrations (GWI3).

Entries

XO. Introauction. Naturnlly occurring forest and brush fires are popularly thought to be encouroged by annual meteorologieal conditions, such as drought and eléctrica! storms. There are "fire seasons" just as there are rainy seasons. However, there also seem to be fire cycles with much longer periods. These are of interest to the anomalist.

Severa] scientists have hypolhesized that some long-period incendiary cycles —decades nnd centuries long----------may correlate with and he caused by natural phenomena----some stiil unidentified— with similarly long periods.

Chínate. of course, is affected by the sun's temporal pattern of emissions, especially the drumbeat of the 11-year, long-studied solar eyele But are there even uther longer cycles pertinent to terrestrial wildfix-e cycles? How do these other phenomena ignite brush and forests?

In the diseussions that follow, we do not knowingly inelude fires due to human arson or carelessness.

XI. Cyclic occurence. Minnesota and probably other northern **States** and Canadian Provinces. An analysis of the sediments, especially charcoal, of three northern takes, has enabled ,T. Clark to identify periodicitíes of forest fires in this región over many centuries.

"The chBrcoal series from 1240-1960 was analyzed with a Fourier series that looked for sinusoidal waves contained in the series. Periodieity in the amount and frequeney of charcoal deposition becamc evident. Cycles of forest fires showed up at 10.5-11.5 years, 33-36 years, and 80-90 years, with severa! minor peaks ín the vicinity of 15-25 years. Also indicoted was o decrease in number of forest fires from 1600-1890 as a result of the cooler, wetter climate of the 'little ice age.’ These cycles can be correlated with the weather patterns and the arnount of fuel available." (RI)

All of tlie above factors are probably associated with long-term variations in solar r8dÍ8tion and the orbit and orientaron of the earth's axis. They con- trast starkly with the near-real-tíme incendiary stimuli in X2 following.

X2. October 2003. Western North America. Solar Coronal Mass Ejections (CMEs), which occur more frequently when the solar eyele is near Jts peak, induce sudden, intense surges of electricity in the earth, especially ds trust and sur- face features.

B.A. Leybourne et al hypothesize that these electrical surges forcé clouds of ionizad gases to be expelled through cmstal fractures. These gaseoua emissions may be igniled by lightning rir

even by Joule-heating near the surface. The result ís seen in spontaneous wildfires at geologically determined spots on our planet's surface; e.g., fault net- works.

Here is one of their proposed exampies oí such a phenomenon.

"The unprecedented wildfire storm in Oetober 2003 occurred simultaneously with a powerful CME. Geospatiat wildfire patterns suggests these wildfires followed fault and geomagnetic anomaly trends associated with the extensión of the East Pacific Rise into the North American continent and Pacific fracture zones traversing the west coast of California." (R2)

More spectacular is ihe 1859 evenl.

X3. 1859. North America and Europe. ”In 1859, during the strongest CME on record, telegraph wires in the western United States and Europe caught fire and were destreved" (R2)

Terrestrial wildfires, then, can be ignited directly in elmost real lime by powerful solar emissions interacting with lengthy manmade eléctrica! conductors.

The geographie distribution of these wildfires, howevcr, tend to follow human-made patterns of infrastructure rather then natural geological faults and eonduction paths.

References

Rl. Stumpf, Melinda, and Kokus, Martin S.; "Fürest Fire Cvcles." Cycles, ■11:185, 1990. (XI)’

R2. I.eybourne, Bruce A., et al; "Gulf of California Electrical Hot-Spot Hypothesis: Climate and Wildfire Teleconnections," New ConcepUs in Global Tectonies, Newsletter, #38:3, March 2006. (X2, X3)

GWI2 Spontaneous Natural Fires

Descríption. The spontaneous ignition of brush, forest and especially human infrastructure. Some of these rnysteríous fires are reported to ha ve been accornpanied by electrical actívity. Omitted here are arson, spontaneous human combustión (SHC), and those common cases of spontaneous combustión of green fodder in silos and the líke.

Data Evaluation. Our data here are almost totally anécdota] and appear in news-^ papers. Direct observation by scientists are missing. as are thorough studies of most of the phenomena reported. Rating: 3.

Anomaly Evaluation. Some of the anecdotes recounted belowseem to belong to the fíeld of parapsychology. For example. one can invoke "fire poltergeists” to explain the spontaneous ignition of human clothing and structures. We will evalúate things parapsychologica! in P-senes volumes of this catalog.

In the anecdotes related below, there are also frequent instanees where human infrastructure has been damaged, set afire. or caused to malfunction by the action of natura] electricity. Such phenomena can often be attributed to electrical currents induced by solar outbursts, as desrribed in GWI1. Rating- 3.

Possible Explanations. Earth currents induced by solar storms.

Similar and Related Phenomena. Cyclic natural fires (GWI1): wide-area confia- grations (GW13); spontaneous human combustión (BHC7) in Biológica! Anomahes 11, supposed fire-poltergeist actívity (Series P catalogs); natural combustión in geology (ESC4 in Anomalies in Geology): enrth-current anomahes (EZC5 tn lnner Éarth j .

Entries

XO. íntroducíion. Any large collection of Forteana wili contain accounts of fires of mysterious origin. Many of improbable fires these seem to involve electricity, natural or should we say "unnatural"?

We eatalog here onlt two of these unlíkely events, but only because they were given a modicum of credence by the New York Times.

Note tbat we have attended to the equally suspect phenomenon of spon- taneous human combustión (SHC) in BHC7 in our eatalog· Biological Anomaliee: Humans II.

XI. Summer 1945. Almería, Spain.
Termed a "meteorological phenomenon," farmers' clothing, buildings and equip- ment suddenly burst into flames. A scientist from the National Mining School ʜ«ꜱ sent to investígate *'

His assessment:

"The activity ís definitely localized in a farming area a short distance from Almería. Farm lnborers working in this area under a traditionally cloudless sky suddenly find their clothing nfire.
Taking off their clothing and stamping out the fue, they find it beginning to blaze again- The outer walls of white plaster buildings eonstrueted of not readily combustible materials also broke into spontaneous blazes. White objeets are most affected." (RI)

Here, one would expect crops and brush to be ignited, not plaster walls. And why were white objeets ignited preferentially? We suppose that "some- thing" did happen since a scientist was sent to investígate and the New York Times thought the incident worth mentioning.

X2. Winter 2003. SiciJy, Italy. Head- lines were made in many newspapers around the world when Sicily seeroed to be under attnck by an electrical Satan.
As in XI, we follow the literary lead of the usually reliable New York Times.

Two days before Christmas: "Fuse boxes blew in houses all along the Via Mare. Air conditioners erupted even when unplugged. Fires started spontane- ously. Kitchen appliances went up in smoke. A roomful of wedding gifts was crisped. Computers jammed. Cellphones rang when no one was calling, and electronie door locks in empty cars went demonically up and down . "

Scientific authorities were called in from the National Instituto of Geophysics and Volcanology, but thev could only hypothesize.

"One Ihypothesis] was that high pressure from under the crust of this volcanic spit of land on Sicily's northern coast had eaused underground shifts that released electrical energy that eventually found its way to the village.

"The supercharged ions, once in con- tact with made-made electronie devices, may have eaused sparks to fly, the scientists say, especially since the hamlet is near transmission lines. But the fírst could just as easily have been eaused by somo unexplainable problem in the atmospherr , Mr. Martella said.

"'The cause of the fires seems to have beeri static electrie charges.' he said. 'What we don't understand is why there were these static electrie charges."' <R2)

In tne compiler's mind, the reported phenomena and profferred explanBtions are unsatisfactory to say the leas!. Per- haps this all belongs in our catalogs on parapsychology, especially a chapter that deais with "fire poltergeists." !

However, harking back to GWI1,
Sicily is riven by many geological faults. The reported phenomena might have been the consequences of a massive solar out- bur6t that induced terrestrial electrical currents in some susceptible modern human infrsstructure.

References

RI. Anonymous; "Spontaneous Combustión Puzzles Spanish Farmers," New York Times, July 5, 1945. Cr. M. Piechota. (?fl)

R2. Baker, Al; "Electricity Goes Wild." New York Times. June 24. 2004. Cr. H.H. Henry, P. Gunkel. (X2)

GWI3 Great Natural Conflaqrations in North America

¡n Human Times

Descripiion. Within histórica! times, multistate-wide firestorms that propágate at high speeds and leap natural barriers. Millions of square miles may br involved. As with lightning, earthquakes, and other powerful natural phenomena, eleetrical phenomena may be involved.

Background. Here, we exelude fire whirlwinds, the weaker natural firestorms and human-created conflagrations, such as the infamous Hamburg firestorrn of World War 11. Our defining example <X1) is the firestorrn that rnged through North Central North America in 1871.

Data Evaluation. Several histories of the 1871 Great Chicago Fire and the syn- chronous ”Peshtigo Horror" in W'iseonsin have been written. However, scientific analysis of this colossal conflagration have been absent from the literature examined so far. The eyewitness anecdotal evidente, however, is detailed and often incredible. Rating: 3.

Anomaiy Evaluation. Intense forest fires frequently advance rapidly and leap wide natural barriers. The ineendiary phenomena described below are extreme and spectacular examples. As common with powerful meteorológica! events, "pranks” and eurious occurrences abound. as they do with lightning and earthquakes. What really entices the anomalist to study firestorms are the frequent tales of accompanying electrieal phenomena. These encourage a relatively high anomaiy rating. Rating: 2.

Possible Explanatíons. intense solar storms may induce fire-igniting earth currents.

Similar and Related Phenomena. Whirlwinds of ñre and smoke (GLD11 in Rernark- able Luminous Phenomena: tornado electricity (GWT1); spontaneous natural fires of mysterious origin (GW12).

Entry

XO. Introduction. Continent-wide wild- fires appear the the geological column. They have coincided with meteor impaets and volcanic eruptions in the deep past. which left behind layers of soot and charcoal in the geologists’ historical record.

In human times, the Tungusko Event of 1908 ignited great forest fires in Siberia. This event is well-documented. (ESC1) in our catalog Anomalies in Geo- logy.) y?e therefore bvpass it here.

Here, we catalog a great conflagration that preceded the 1908 Tunguska Event. It did not have Tunguska’s global eon- sequences, but few North Americans today are aware of the horrific fire that ravaged North Central North America in 1871. The Great Chicago fire of the same daté may ltnger in sume modern rninds along with the famous tal» of Mrs. O’Leary’s cow! Wut', in truth, the Great Chicago Fire was just n sidebnr to the story of a much larger conflagration.

We herewith reetify this gap in our modern brain-stored collective knowledge of the 1871 fiery catastrophy by merging four digosts of ítems that appeared in past issues of our newsletter Science Frontiers. Of course, there is some repi- tition, but the various descriptions of the 1871 events and the different anee- dotes nicely portray the great natural calamity of 1871 —a synthesis of the Great Chicago Fire and the so-called Peshtigo Horror, plus the seas of fire that surrounded these two locations.

lf town-engulfing fires were the only charocteristic of the 187] event, we would pos? it by. However, strange phenomena abounded. Some of these seem to have been electrieal in origin. Possible ties exist, therefore with the phenomena recounted above in GW11 and GW12.

XI. October 1871. North Central United States. "Duríngthe great fire that raged over northern Wisconsin in 1871, and which wiped out not only the prosperous village oí Pesti- go, but, ín the aggregate of farmhouses, half a dozen villages like Pestígo, therewere many evidence6 of electrical phenomena pre- sent. The flames were seen to possessthat sudden rapidity of action which only electri- city can impart. They would leap over wide spaces with the greatest rapidity, leaving many objects in the rear thal one would sup- pose could not escape, and striking others beyond, and least exposed, in the most un- accountable manner. The detaíls of that great disaster would dlsclose many curious and instructive facts. People were found dead without any apparent injury, though ly- ing out in the open ñelds, and far from the burnt woods. Of course, it is popularly sup- posed that these suffocated in the superheated atmosphere. However that may be, one cir- cumstance coming under my own observation proves conclusively the presence of electricity, and a very curious action of the subtle fluid, too. Shortly after the fire, the editor of the Green Bay Advócate exhibited a copper coin taken from the poeket of one of the victims found dead in the middle of n iBrge clear- ing. The coin wus fu sed, but no sign of injury whatever wos discovered on the man's person. (Bl)

Dr'scribing ".. the most disaste- rous fire period in our nation's history. " "In Michigan, 2. 5 million acres of timber lay charred, and perhaps 200 people died there.
A complete tabulation was never made. In northeast Wisconsin, 1.25 million acres of timber was destroyed, and about 1,300 people died. In Chicago, where a detailed survey was made, 17,450 buildings were destroyed and over 200 people were kiíled. The major ques- tion ls: With relatively light winds reported in much of the fire area the evening of the 8th, what caused the rapid, high-burning phenomena in most places? In northeast Wisconsin, the major fire run was fínished by 0200, 9 October, leaving a Virgin forest in smoldering ruin. In some sections of Chicago, the rale of fire ad- vance was clocked al 100 yards per minute, and there were reports that the whole horizon was one line of fire." (R2)

We now turn our full attentíon to the northern section oí the 1871 event, which also burned as Chicago was con- sumed.

October 8, 1871. Peshtígo, Wisconsin. The "Peshtigo Horror." October 8, 1871, was the date of two mímense North American eonflagrations: the infamous Great Chicago Fire and the so-called Peshtigo Horror, the latter a fírestorm that incinerated some 2,400 squnre miles of Wisconsin and over 1,000 human beings.
The sumnier of 1871 had been tinder-

*Jn its Hovember **25,** 1871, issue, Harper's Weekiy tried lo capture the Peshtigo Horror with this sketch. **<K** 6)*

di y in the upper Midwest, so fires were not surprising; but two colossaJ fires on the same day? "Just coincidence" is mainstream thought, buf others opt for ígnitíon by a eornet or perhaps sorne electrical phenomenon. (See, for ex- nmple, M. Waskín's lí)85 book Mrs.
O'Leary's Comet). *1

We also liave at band a 26-page eye- witness account of the inferno that swept over the small town of Peshtigo and surrounding areas. Three phenomena recounted therein by F. Permin are of interest to anomalists.

(1) "Many circumstances tended to prove that the intensity of the heet produced by the fire was in sorne places extreme, na> unheard of I have al- ready mentioned that the flnmes pur- sued the roots of trees into the very depths of the earth, consuming thern to the last ineh. 1 plunged my cañe riown into these cavities, and convenced myself that nothing had staved the course of combustión save the utter want of anything to feed on. Hogsheads of nails were found entirely melted though lying outside the direet path oí the fíame?. [Note that the hogsheads were not consumed hy the lire')

(2) "Strange to say there were many corpses found, bearing about them nú traces of sears or burns, and yet in the pockets of their habiliments, equaily uninjured, watclies. cents, and other articles in metal were discovered completely melted.

(3) "When the hurricane burst upon us, many, surprised and terrified. ran out to see what was the matter. A number of tlicse persons assert that they then witnessed a phenomenon which may be classed as marveious. They saw a large blnck object, resembling a balloon, which object revolved in the air with great rapidily, odvnncing above the summits of the trees towards a house which it seemed fe single out for de- struction. tlnrrly had it touched the latter when the balloon burst with a loud report, líke that of n bombshell, and, at the same moment, rivulets of fire streamed out in all directions. ”
(R4)

The preferentia' telting of metal objeets is one of U "pranks" of iight- nlrig, The large blacK ″tlalloon″ could have been n fire tornado, a phenomenon sometimes seen in forest fires.

Focussíng again on the Wisconsin fires: As Chicago burned, a much greater fire incinerated 2,400 square miles of forept in northern Wisconsin. (This area is twice the size of Rhode Island!)

In 1871, the part of Wisconsin was sparsely popuiated. yet about 2,500 peo- pie failed to reach the relative safety of the many rivers and lakes in the area. Those who sheltered in their storrp shel- ters were cooked. Those who lowered themselves into their wells were killed when the burning structures at the surface fell in on them. Even those lucky enough to reach deep WBter had to keep duckíng under to keep their scalps from being pinged. The accompanying fire tornados swept whole houses 100 feet into the air. Residents of Baltimore, over 1.000 miles away, noted the smoke in the western sky.

Bizarre storíes emerged after the conflagration. One of the saddest is that of a man who had just seen his wife die horribly. Fenring for himself and his three children, he slit their throats and then his own. In the end the fire skip- peri over them! (R6)

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GWP ANOMALOUS PRECIPITATION

Key to Phenomena

GWPO Introduction
GWP1 Precipítation from a Clear Sky
GWP2 Giant Snowflakes
GWP3 Snow: Some Anomalous and Bizarre Forms
GWP4 Hailstones with Anomalous Geometries
GWP5 Giant Hailstones
GWP6 Hail Strew Patterns
GWP7 Slowly Falling Hail
GWP8 Unusual Inclusions in Hail
GWP9 Explosivo Hail
GWP10 Colored Precipítation
GWP11 Luminous Precipítation
GWP12 Point Precipítation
GWP13 Surplus Ice Crystals in Clouds
GWP14 Decrease ot Raintall with Increasing Altitude
GWP15 Rain Gushes Associated with Líghtníng
GWP16 High Frequency ot Wet Weekends along the North American East Coast
GWP17 Future Raintall Correlated with Soil Temperature

GWPO Introduction

What makes precipítation anomalous? The major variables involved are color, shape, size, intensity, and distríbutíon. Huge hailstones, red rain, and prodigious concentrations ofrain- fall are obvious candidates for this chapter. But any form oí precipítation without clouds visible in the sky must also be considered anomalous. True, very fine íce crystals can be frozen out of clear air when the coid is intense, but where does cloudless rain origínate? Evidently, the atmosphere can carry considerable moisture without the formation of ielltale clouds.

Colored rain, snow, and hail are rather common---------so frequent, in fact, and so well-ex- plained that they receive only passing notíce here. The European ”rains of blood," described since history began to be written down, and made much of in Fortean circles, can usually be blamed un dust blown north from Africa. Black rain is even more common and can be ascri- bed to forest fires, voléanos, and urban pollution, just as the closely related dark days (GWD) are.

Uncolored rain can, on occasion, be very intriguíng. Fantastic examples of “'point rainfall" and supposedly collapsing waterspouts have been noted often in meteorológica] magazínes. The naming of the phenomenon does not, of course, explain the unbelievable quantities of water that is sometí mes dumped in very small areas. Some sort of meteorological-topo- graphical focussing effect seems to be at work here.

Hail is notable if ít is unusually large, if it comes in odd sbapes, and if it contains inclusions

that should not be present inside ice partióles faUlng from the skv. (Note that isolated ice falls and "hydrometeors" are dealt \vith in GWF1.) The fantastic variety of hailstone shapes: erystals, dises, large fíat plates, spiked spheres. etc. , may indícate the work of unappreci- ated forces in hail formation. Some of these formative forces may be electrical in nature.
Gn a larger scale, the. peculiar mesh and paralleMine patterns of some hail falls cali for explanation in terms of hailstorni dvnamics. Finally, the phenoinenon of slnwly falling hail is not easy to explain.

As in many other weather phenomena. electricíty seems to play a subtle role. Electrically charged precipitation that sparks and snaps upon bitting the ground has been observad on many occasions. Given the powerful electrical-charge-separating mechanism of the active thunderstorm, electrically charged rain is pprhaps not too surprising. But can these same electrical forces also initiate the eurious gushes of rain correlated with líghtning flashes?
The possibility of lightning-indueed rain gushes has long been debated and may be related to those hydrometeors that fall just after líghtning flashes (GWFl) and hot air blasts experi- enced in thunderstorms (GLL12).
A significant general observación concerning precipitation anomalies will be obvious after perusing this chapter: Precipitation phenomena as a class are not especially anomalous.
Thev are interesting, sometimes startling, but do not really shake the foundations of meteoro- logical theory.

GWP1 Precipitation from a Clear Sky

Description. The fall uf rain, snow, or hail from a cloudless or nearly cloudless sky.
Baekground. The descent of tiny ice needles in the arctic regions and on htgh mountain ranges is fairly common. In these regions. the extremely low temperatures cause water vapor to crystallize and fall without the formation of visible clouds.

Data Evaluation. Many sound observatíons of precipitation from cloudless skies are on file. Rating: 1.
Anomaly Evaluation. The thermodynamic condítions for the condensation of water vapor in the atmosphere are well known. What is lacking, except in the fall of ice needles, is a suit- able, possíblv short-lived, meteorológica! mechanism that causes precipitation without cre- ating visible clouds. Since several possibilities exist (see below), precipitation From a clear sky is more eurious than anomalous. Rating: 3.
Possible Explanations. Transient atmospheric disturbances, such as gravity waves and the sudden expansión and cooling of wind blowing across mountain ranges. Large influxes *oí* meteoric dust may also stimulate. precipitation. Some spurious instances of precipitation from a clear sky may derive from wind-blown precipitation from distant, unseen cloudj, from ocean breákers, and even from waterfalls. Occasional pseudoprecipitatkm occurs on wirm fall days in vvooded áreas when sap exudes from leaf scar3.

Similar and Related Phenomena Nono.

Examples of Precipitation from a Clear Sky

XI. April 23, 1800. Philadelphia, Pennsyl- vania. "A shower of rain of at least twenty minutes' continuance, and sufficiently plen- tiful to wet the clothes of those exposed toit, fell when the heavens immediately over head were in a State of the most pertect se- renity. Throughout the whole of it, thestars shown with undimished lustre. Not a cloud appeared, except one to the east and another **tt** the west of the citv. each about fifteende- grees distant from the zenith. ” (R3) In this instance wind could have blown the rain hor- izontally from the extant clouds.

X2. November 13, 1833. Harvard, Massa- chusetts. "At Harvard, in this State, at about 8 o'clock on the morning of the 13th, there was a slight shower of rain, when not

a cloud was to be seen, the weather being what ls called perfectly fair." (Rl, R3)
This observation is signülcant becauae it occurred immediately after one oí the grea- test meteor showers in historical times. (WRC)

X3. August 9, 1837. Geneva, Switzerland. Several short showers of tepid drops of large size. (R3)

X4. May 31, 1838. Geneva, Switzerland. A lukewarm rain lasting 6 minutes. (R2) X5. April 21, 1842. Flanders, France. (R4)

Xb. July 26, 1855. Ostend, Belgium. (R5) X7. April 17, 1857. París, France. (R6)

X8. July 22, 1888. Stevenage, England. Rain from a cloudless sky preceded a vio- lent thunderstorm by 1 1/2 bours. "The ap- pearance was first seen about 7 p. m., aod it looked like a shower of luminous particles of a somewhat sklm-milky appearance. As soon as 1 realized the fact of ¡ts electrical nature I endeavoured to ascertain ¡f the movement of the particles was upwards or downwards, bul without effect. But what J did more succeBsfully observe was that the particles were of the size of tare-seed, and that they moved in remarkably straight línes, so much so that they resembled the warp in a weavers frame. My view extended over about two-fifths of the circle of the heavens, and the appearance withm that area waspre- císely the same." (R7)
The luminous nature of the phenomenon is unusual and somewhat resembles low-level auroras and aurora! fogs (GLA4 and GLA21). (WRC)

X9. 1892. England. (R8)

X10. February C, 1895. Surrej^{r}, England. "On the 6th February, at 9 a. m., light snow began to fall, sparkling in sunshine from a cloudless sky. Thinking that the snow might be blown off a roof, I went out on the common, clear oí houses, and made no doubt that the fall was from the sky. Grad- uaJly ¡t clouded over, and at 10 a.m. was quite overcast, the snow continuing as a natural shower for a short time longer.
(R9) In Sussex it was a brtlliant day, with snow crystals and minute spiculae of ice falling at intervals. (RIO)

XI1. 1902. Tarbes, France. "...after a day of mist and rain, with low temperature, the sky cleared and the níght becaroe fine. This lasted till midnight, when the town wat» suddenly deluged with hail, the streets being thlck with stones of large size. The most singular feature of this meteorológica) freak was at the time the hail fell there was an absolutely clear star-lit sky. "(RII)

X12. July 18, 1925. Boveysand, England. A very short, localized shower from a blue sky. (R13)

X13. December 29, 1929. Grayshott, England. A few minutes of drizzle from a clear sky with bright stars. (R15)

X14. January 3, 1933. Grayshott, England. (R15)

X15. January 20, 1935. Benson, England. Drizzle from a palé, watery-blue sky. (R14)

X16. February 5, 1955. Wrexbam, England. "On February 5 there was a period of light rain from 2130 to 2230 G. M.T. The cloud then euffered a complete and rapid dispersal, and from 2235 to 2255 light rain continued to fall from the cloudless sky. Not a trace of cloud could be seen and the stars were as bright as they can be with a nearly full moon, and it was calm at the surface. The rain was not heavy enougb *to* be regístered on theauto- graphíc rain-gauge, but was sufficient to wet clothing. ” (R16)

X17. February 15, 1955. Wrexham, England. Snow fell in the absence oí low clouds, although higb cirrus were pre- sent. (R16)

X18. January 1, 1979. Houwaart, Belgium. After an extremely coid night, ice needles fell from a clear sky. (R17)

X19. General observation. The slow fall of ice needles (so-called "diamond dust") from a cloudless sky is rather common in polar regions and on high mountalns. (R12)

X20. April 26, 1887. Argentan, France. At 8:00 in the evening, the sky was absolutely clear Hnd the stars shone brilliantly. All of a sudden, rain drops fell in the area for 5 minutes. (R18)

X21, December 28, 1986, Ross Island, Antárctica. No detectable clouds from horizon to horizon. For at least 4 hours, ice crystals fell in the form of hexagonal
piales. Many were large----------up to a milli- meter across. The crystals, being so large, fell rapidly. Their density was estimated al 5-10 crystals per liter.

The reason the nucleation and crvstal growth did not occur in a visible cloud layer is no doubt that whilst the aír beceme saturatprl with respect to ice, at no stage was was it eatu- rated with respect to liquid water.
(R19)

Under such conditions, rather common ín the polar reglons, ice erystals can form but the liquid droplets that fortn clouds eannot.

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GWP2 Giant Snowflakes

Description. Large agglomerations of smaller flakes in the form of plate-like masses measuring up to 38 centimcters in diameter.

Data Evaluation. Aggregations of flakes 2-4 inches in diameter are common; those 4-6 inches in diameter are rare but well-verified. The record flake, 38-centimeters across (X2^ may be an exaggeration, but no one contests the íact that immense snowflakes do fall under some conditions. Rating: 1.

Anomaly Evaluation, The aggregation of snowflakes by collision poses no problems for geo- physiclsts; large flakes fall faster than small ones and, in so doing, pick up more and more smaller flakes. One observation suggests that electrostatic attraction may play a role, but even bere there are no theoreticai problems, because ¡t has long been accepted that snowflakes may earry substantial electrical charges. Rating: 3.

Possible Explanations. Large flakes are probably aggregations of smaller flakes created by collision and/or electrostatic attraction.

Similar and Related Phenomena. Electrical discharges observed during snowstorms (GLD5).

Examples of Giant Snowflakes

XI. January 7, 1887. Chepston, England. Some ílakes measured 9 centimeters in díameter, larger ones seen. One flake yielded 16 drops of water. The flakes consisted of hundreds of undamaged cry- stals set together at all angles. The ob- server thought he saw the large flakes exerting an attractive forcé on smaller ones. In part, though, the giant flakes could be explained in terms of the buge flakes overtaking and combining with the smaller ones. (R2, R4)

X2. January 28, 1887. Fort Keogh. Montana. Huge flakes "larger than milk pans" and measuring 38 centlmeters across bv 20 centimeters thick. (R2. R4, R6)

X3. January 24, 1894. Nashviile, Tennessee. Some flakes almost 14 centimeters in di- ameter. (R2, R6)

X4. March 25, 1900. Richmond, Virginia. "There wae nothlng unusual about the first falls of flakes, but the sleet immediately di- mínished in volume and as this occurred the flakes increased in slze until they attalned unusually large dimenstons. They were of irregular shape, usually oblong; several were observed whose greatest diameters could hardly be covered by a teacup (perhaps about 7.6 centimeters). Some of theseflakes were caught upon a piece of dry wood and ex- amined: in every instance they showed the center to consist of a soft mass of snowabout one-half inch (1.3 centimeters) in dlameter.

wliile the outer edges were thin, as though they were sepárate flakes that had attached themselves to the central mass while it was falling. The greater weight of the center caused the larger flakes to assume the form of an inverted cone as they fell, the outer, thinner edges being bent upward by the resis- tance of the air." (R2, R4)

X5. January 17, 1912. Bristol, England. Some flakes were 3 1/2 inches in diameter. (Rl)

Xb, January 10, 1915. Berlín, Germany. "On thís oceasion a large number of snowflakes had diameters of 8 to 10 centimeters, and these giant flakes fell with both a greater

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smaller flakes. They did not have the com- plieated, flutterlng flight of the latter. In form the great flakes resembled a round or oval dish with its edges bent upward. During flight they rocked to this side or that, but none were observed to tum quite over so that the concave side became direeted downward. "

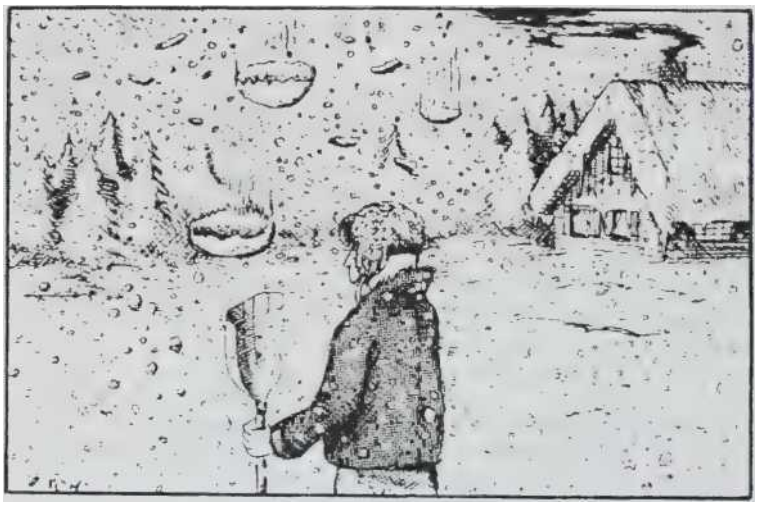
(R2)

X7. April 13, 1951. Berkhamsted, England. Enormous flakes about 5 ¡nches across. **(R3, R4)**

X8. March 24, 1888. Chepstow, United Kingdom. 9) centimeters. (R4)

X9. September 24, 1970. Laramie, Wvo- rning. 6 centimeters. (R4)

X10. January 30, 1942. Derbyshire.



Snow//a/tes 38-cm in diameter fatl in Montana <X2t

United Kingdom. 5 centimeters. <R4) Xll. Drcember 9, 1950. Sapporo. Japan. 5 centimeters. (R4)
X12. l'ebruury 22 , 1986. Holifax, {.anada. 5 centimeters, <R4>

X13. Winter 1971. Rratsk. Siberin. "Now aeeepted os fnot in the weather records was the report that the Siberian town of Bratsk in the winter of 1971 got snowflakes as big as footballs." (R5)

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GWP3 Snow: Some Anomalous and Bizarre Forms

Description. The creation by meteorological forces of an immense variety of wildly different snow crystals, some wíth high symmetry and great beauty, all from a single molecule-—water.

Data Evaiuation. Some forms of snow, notably the stellar dendrites, have been collected, drawn, preserved, and studied for centuries. But some equally per- plexing forms of snow, sueh as the capped columns, have received far less analysis.

While the beauty of snowflakes received much attention, Two of the major anomalous aspects of snow, outlined below, have been mostly ignored by Science. Rating: 2.

Anomaly Evaiuation. We recognize tbe following two anomalies connected to snow formation; there may be others:

(1) The primary anomaly is the unexplained and scarcely attended to creation of long-range symmetry in snowflakes: in a nutshell, how do the six arms of stellar dendrites intercommunicate to achieve near-perfect duplication of complex designa when separated by diBtance[7] Rating: 1.

(2) The source(s) of the beauty. bizarreness, and complexity of the many forms of snow are not well-known. Admittedly, these are human subjective para- meters, but as with biodiversity and the universal love of Ufe forms, we would üke to understand how they come about and why. No paradigma are at risk here. We desire to come to grips with the efflorescence of Nature. Rating: 4.

Possible Explanations. Long-range duplication of snowflake geometry may be guided by lattiee vibrations, electric ñelds established by the seed crystals, or, possibly, the eurrently unaccepted hypothesis of morphíc resonance as advaiieed by R. Sheldrake.

As for beauty, bizarreness, and complexity, the multitudinous forma of water and the vagaries snowstorm conditions probably provide sufficient variables lo sculpt ice crystals with the properties presented above. Science finds it diffi-
cu.lt to deal with the questiona of why Nature is often beautiful and diverse----------
at least to us. AnswerB to such questions may always elude us.

Similar and Related Phenomena. The long-range order in all crystals (COC in a future volume); curious and anomalous forma of hail (GWP4); the origin of biodiversity (Seriea-B catalogs); the self-organization of other simple molecules into other beautiful, bizarre, and complex crystalline forma not associated with snow; hoar-frost and froat figures.

Examples

XO. Introduction. The popular visión of snow is that of the elegant six-armed snowflake. These are common in many, but not all, snowfalls. They come in seerningly infinite, often very beautiful variety. Scientists eustomarily term these forms of snow "steller dcndrites."

Rarely, though, do the popular and Science media attend to the several other kinds of snow: the needies, the columna, the sectored plates, the "bullets," etc. These neglectcd forms oi snow are often just as beautiful as the lacy, highly syrometrical, six-sided. dendritic stars that everyone uses to typify snow. To anyone trying to understand snow forma- tion, these other forms are equally challengiug and beguiling.

We describe tlie most interesting types of snow in a general way in X4 below. After inteLlectually absorbing snow's great variety and structural complexity, one sees how difficult it has been for Science to explain exactly how Nature conceives such a wide array of shapes and designa and then manufactures them in immense multitudes in the tumult of a snowstorm.

We begin somewhat indirectly with entries X1-X3. These ave event-type entries detailing falls of so-called "conical snow,"

Puré conical snow consista of tiny snow crystals packed into soft, easily cruslied cones which usually have rounded bottoms. They fe-el and look like snow. But a taxonomie problem arises here because some conical snow pelleta have conical cores of clear ice. These seem to be transitional forms be- tween puré conical snow pellets and the solid ice of conical h8il. (See, for ex- amplp, GWP4-X25.) We have cataloged just three cases of puré conical snow in X1-X3 and continué with the transí- tional forms and puré conical hail in GWP4, wliere many additionaJ hail anom- alies and curiosities are cataloged.

Are Hny of the various forms of snow described below anomalous? Some snow shapes, such as the enpped columns (X4), certainly perplex those meteorologists trying to identify the specific weather conditions inside n snow storm that can generate untold millions of copies of the various bizarre forms of snow.

While the meteorologists are musing over the many curious forms of snow, a much more serious problem of explanation bedevils most snow geometries, even the common stellar dendrites. It all has to do with our poor understanding the growth of crystals, which of course in- cludes the many crystalline forms of snow. This subjecl actually transcends meteorology and is therefore covered in more detail in Section COC in a future volume. Here. we only sketch out this problem by quoting J. Maddox writing in the journal Natore.

After reviewing the great difficulties scientists are having in mathematically describing the growth of even the simp- lest crystal, Maddox honies in on the fascinating pvizzle of snowflake growth in technical terms.

"The aggregation of particles Into a growing surface will be determined ex- clusivelv by local properties, among which surface tensión and the opportuni- ties for energetically advantngeous migration will be important. But the symmetry of a whole crystal, represented by the exquisita six-foid symmetry of the standard snowflake. must be the consequenee of sorne cooperatíve pheno-menon involving the growing crystal as a

whole. What can that be? What can tell one growing face of n crystal (in three dimensions this time) what the shape cf the opposite face is iike? Only the lattice vibrations which are exquisitely sensitivo to the shape of the structure in which they occur (bul which are almost incaico- lable if the shapes are not simply regular)." (R4)

More simply. how does one arm of a six-armed snowflake know what the other growing arms look like so that ít can duplicate them? Is some sort of universal duplicating "forcé" at Work[9]

In his forgoing diseussion of the source of snowflake symmetry. J Maddox invokes tnechanical vibrations to communi- cate structural instructions among the six arms of dendritic snowflakes 3n re- sponse to Maddox's concerns, two let- ters to Nature suggest that electric fields establílhed by the snowflake nucleus might enforce the observed symmetry. (R5)

More specifieally, VV.S. Mortley re- marked: "It is unclear to me why there should be nny need to invoke lattice vibrations to tell one growing face what the shape of the opposite growing face ic like. lt does not have the need to know. In a statistically uniform environ- ment of many particles, stntistics and electric fields wül shape all six growths uniformly." (R5)

We do not know if Mortley's far- reaching claim has been demonstrnted experimentally.

It would be remiss not to mention R. Sheldrake's controversia! hypothesis of morphic resonance in connection with snowflake symmetry. Sheldrake suggests that the mere presence of a specific shape creates a universal "field" that eneourages th.e duplication of that shape elsewhere. tRlO) Needless to say, Shel- drake's hypothesis has been rejected by most scientists.

XI. April 2f», 1931. Ann Arbor. Michigan. Three short lalls uf conical snow. "The crvstal formation was that of a solid cone with a round base. The sirle of the cone made an angle of about 30 degrees with the axis. The round base was parí of a spherí cal surface. The shape was exactly ltke that of a cónica! section oi a spheie. As nearly as the eye could see tnto the forrna- tion of a snowdrop, the whole structure seemed to be made up of conical needles, packtd together, with the upper ends íur- ming the pointed tip of the cone, and the larger lower ends forming the roundedbase. The density was very high; a handful of snow, slightly compressed, imrnediately formed Soft ice. The ratio of snow volume to vol- ume when compressed to ice without alr in- cluded would hardly have been higher than four to one. Hundreds if not thousands oí Individual snowdrops carne under observaron on a window sil]; irrespective of size, from tiniest to largest, the crystals were
of the same fovm------Many large crystals fell; one of the largest. by actual measure- ment, was three eighths of an inch across the base. ” (Rl)

X2. September 1920. Ephraim, Utah. Cones of hard, compacted snow with hemispheri- cal bases—like inverted parachutes. A1J measured more than 1/4 inch across the base, with many reaching l/2 inch. They were definitely snow and not ice. (R2)

X3. Regular occurrence- Northern Vermont. Several ialls of conical snowflakes re- corded each year, They come only from cumulo-nimbus elouds, have a granular texture, and are built. up from under- cooled eloud droplets that have frozen together. The nuelei are almost always branching tabular crystals. (R3) This descríption does not seem like that of XI as far as internal structure in concerned.

X4. A roster of major snow types. All of the types of snow mentioned below are subject to J. Maddox's concern expressed above about our poor underptanding cf the duplication of shapes in snowflakes. (XO)

Some of the shapes of snow Usted below are undeniably bizarro and improbable. But bizsrreness is not an indica- tor of enomalousness. Yet. we still must wonder how a snowstorm's varying meteorological parameters can mold so many different odd shapes ín such immense numbers. As with evoíution's creation of biodiversitv, the snowstorm al so seems infinitely inventlve bul, of course, it is actuaíly very límited. 15 lacks mutation and natural selection and depends only upon the vagaries of temperatura, pressurc. humidity. and the amazingly varied propertíei- uf water in its solid, liquid, and gaseous forma —the diverse properties of a single molecule. bife, in contrest has the entire periódica! table at its beck and cail!

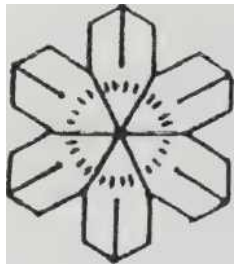
Below, ín the reviow cf the forras of snow, we rely upon the classifícation of K . Libbrecht and his associated de- finitions. (R7)

•Diamond dual. Hexagonal prisma of ice that form in very coid air, such as ís found at very high altitudes and in the polar regions. Diamond-dust crystais Bre usuelly less that o millimeier in size —almost invisible to the naked eye.
They may drift to earth when the polar sky seems cloudless.

•Stellar dendrites. These icons of winter are very thin, six-armed ice crystais rarely exceeding i-inch in breadth. They begin as tiny hexagonal ice prisms. Their longish, highly sym- metrical arms grow out radially from the six-sided seed crystais. The seemíngly endless vnriety of arm geometries gives the stellar dendrites a fiower-like ap- pearance. Iconic though thev are, they are absent in many snowfalls. Their high degree of symmetry, as explained in XO, constitutes their major anomaly. But beyond that the curious among us must also wonder what "forces" introduce such variety and beauty into the síx growing arms; that is, "ice-crystal diversity."

Stellar dendrites become more complex, though not more anornalous, when they are found with 12, 18, or 24 arms. The 12-sided dendrites are believed to result from twjnned seed crystais twisted 30° apart. The twin crystais grow together, both six-Brmed, but 30° apart, resulting in a 12-armed stellar dendrita. It is more difficult to account for the rarer 18- and 24-nrmed varieties.

•Sectored plates, sometimes called "brond-branched" crystais, may be rnixed in a fall of stellar dendrites. In fact, msny sectored-plate flakes resemble stellar dendrites with six, broad. fíat arma, but less elegant in design. At the other end of their simpe spectrum the sectored plates are simple hexagonal plates of thin ice divided into six sectors by ice ridges. In between these extremes there is a constellation of six-armed crystais displaying varying degrees of "píate-ness."



•Needles and columns. Sometimes, the embryonic icy nuclei of snow-to-be grow faster at the two ends of the hexagonal seed crystal. This chango from six-fold growth from the faces to two-dimensional end-growth results in long needles and columns rather than stellar geometry. Needles and columns are very common in snowfalls but generally neglected by the media in favor of the more attractive six-armed dendrites and sectored plates.

Some of the falling ice columns may, for some reason, be hollow. Something else that needs explanation.

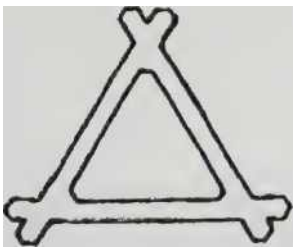
Sometimes, columnar crystalB grow in clurnps. When the sepárete crystal columns break apart and fall, they are often bullet-shaped, each with a pointed end where they were joined to the clump.

•Capped columns. Rather improbable producís of Nature are the capped columns. At their cores, thev are simple ice columns. but perhaps due to clianges in a storm's temperatura and humidity, columnar growth ceased and was replaced by the superposition and growth of hexagonal end caps. A truly bizarre Torm of snow results. None of the snow shapes described above can surpass in strangeness the capped columrn in the aecompanying illustration.

Rere we see the hexagonal symmetry retained in columnar core and again in the platea at each end of the iey dumb- bell. But whot are those peculiar ice- worms projecting from the end plates?
The answer is (probably): strands of "rime." (See "Oddities" next.) (R7,
K8)
What combination of meteorológica! mechanisms can scuplt such complex shapes in prodigious quantities?

•Oddities. Capped columns do not end the roster of snow odditiea.

Asymmetry frequently is seen in snow- fiakes, resultirig in distorted flakes. Breakage of the delicate stellar dendrites yields so-called "splits," such as 3- armed stars. Snow often falis ínto re- gions occupied by íiny droplets of liquid water. These may adhere to the falling flakes and fveeze into miniscule beads or even tiny hexagonal platea, thus marring a stellar dendrite's beauty wíth a de- posit of "rime." Heavy deposita of rime completely change the shape of a den-



drite. It then becomes a lump of soft snow or "grauple." R7, R9)

In addition to colliding with droplets of liquid water, snowflakes may impact one another. The two flakes may fuse and grow together into confusirig hybrids often with grotesque shapes. (R7)

X5. Biological snow! To form at all above -40°F, snowflakes require a solid seed or nucleus around which n seed ice crys-
can form-----or so scientists have assumed fnr manv years. lt was long believed that airborne dust, perhaps augmentad by extratcrrestrial micrometeoroids, served as the necessary seed crystal nucleí. But cloud studies proved that there are about a thousand times more ice crystals aloft than dust nuclei. Now, some scientists are convinced that bacteria blown off piants by wind and flung into the air from the ocean by breaking waves are the true nuclei of atmospheric ice crystals and, of course, water droplets as well.

Remember this the next time you taste a handful of snow or let raindrops fall on your tongue' (R6)

The pogsibility that the fall of snow and all other forras of watery precipitaron is largely dependenl upon airborne bacteria brings lo mind the tlaia Hypothesis; that is. all life forms work in unisón to further the welfare of Ufe- as-a-whole. In this vein. airborne bacteria support this goal for our planet by fostering preeipitation.

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GWP4 Haiistones with Anomalous Geometries

Deecription. Haiistones that depart substantially froin the usual roughly spherical georoetry, which is often constructed from concentric sheüs. The variety of oddly shaped hail is astounding. It rangea from georaetrically satisfying hexagonal crystals to bizarre Dali-like shapeB. Some of the more common anomalous shapes are coneB, pyramids wlth rounded bases, fíat platea, and starñah ahapes.

For the reader’s guidance, we add here a table of the major vaieties of hail encountered so far in our literature searches. Entry numbers are in parentheses.

Crystalline hail: cubes, long thin hexagonal prisma, aggregates of hexagonal crystals (X1-X7, X9-X11, X14, X53, X62, X63)
Cónica] hail: rounded bases common, some with ice-needle structure (X19-X25, X61, X70, X71, X73; see also, GWP3-X1-X3))
Spiked and starfish hail: (X26, X27, X32, X33, X36, X52)
Knobbed spheres: knobs arranged geo- metrieally (X28, X29)
Fiat plates, sheets, blocks: (X38-X42. **X67)**
Large, thin flakes- (X43)
Perforated hail: (X44, X45) ned-blood-cell-shaped hail: (X46) Cylindrical hail (X47, X63. XB5)
Tubular hail: (X74)
Convex-lens hail; (X48, X58) Button-shaped hail: (X49)
Kmged-spherical hail; i.e., Snturn-like geometry: (X50, X51)
Hail shells filled with water: (X56)
Hemispherical hail: (X57)
Bullet-shaped hail: (X63)
Nested hexagonal pyramids: (XH4) Hexagonally aggregated spheres- (X68) Teardrop-shaped hail: (X69) Six-pointed-star-like flakes with hexagonal holes in centers <X75)
Lenticular hail with circumferences of pyramidai crystals (X8)
Spheres with nested tetrahedral pyramids with rounded bottoms. These may break apnrt into sepárate crystals (X12, X13 , X15-X17, X20)
Irregular and bizarre hail: eataloged onlv when similar "geometries" fnll in large numbers: ÍX30, X31, X34, X35, X37, X52, X54, X55, X59. X63. X66, X72)

Background. Hail is usually thought of as water droplets that freeze in the atmo- sphere as they fall to the ground. A storm's air eirculation may carry haiistones repeatedly through regions where additional ice is added layer by layer. Crystalline forme of hail, espeeially in aggregates like those seen in minerological dis- play cases, are considered anomalous because crystals usually require long periods of time to grow to the sizes reported beiow. Such conditions are not typical of hailstorms.

Data Evaiuation. Most of the anomalous and bizarre forma of hail descríbed here have been carefully observad, often drawn, photographed, and accurately measured. The older Science literature is fuil of such hail anomalies. Today's weather journals pay little attention to them. Rating: 1.

Anomaly Evaiuation. Our rather large collection of hailstone anomalieB focuases on the following challenges to mainstream theories of hail formation.

(1) Large crystals and aggregates of crystals grow to appreciable aizes in the tumult of a hailstorm. Thi6 is unexpected. Rating: 2.

(2) Some hailtones are hollow or have holes in their centers, suggesting that they grew wíthout a nucleus or, perhaps. that the nucleus was somehow lost. Crystals (and raindrops) are thought to require nuclei to grow. Rating: 3.

(3) Some hailstones depart from the sixfold symmetry that dominates water- crystala. A major deviation is seen in the many examples of conical hail.
Rating: 2.

(4) Bizarre, freakish hailBtones are reproduced almost identically in great numbers in aoroe hailstorms. Whatever their mechanism-of-formation is. it repeats chuma out the same bizarre ahapes seemingly endlessly. This mechanism must be coroplex and is hard-to-ünagine. Rating: 2.

One cannot dismiss all of the anomalous hailstones aa occasional freaks.
They descend in storros all over the world----------repeatedly. Even so, meteorology generally ignores them as more vagaries of Nature.

Possible Explanations. The multifold properties of water and the rapidly changing environment in a hailstorm present a cornucopia of variables with which to fashion anomalous hailstones. Probably, many of the anewers we search for m hail formation are inherent in these variables.

Similar and Related Phenomena. Anomalous snowflakes (GWP3); hydrometeors (GWF1); crystal-growth anomalies (COC in a future volume).

Examples of Anomalous Hailstones

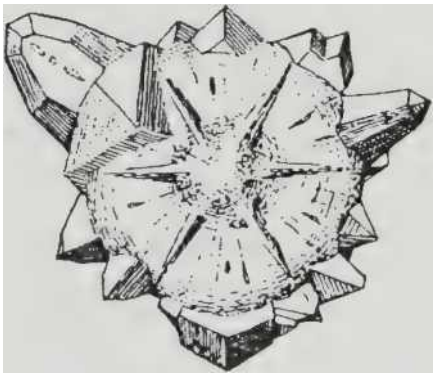
XI. 1769. París, France. Crystalline hail fallí. (R21)

X?. August 26, 1834. Padua, Italy. Crystals about 1 1/2 inches iong in the shape of four-sided prisms, one side of which was very narrow in comparison witb the other three aides. Each prism terminated in a four-sided pyramid. (R4)

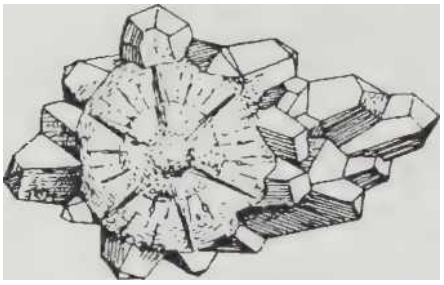
X3. 1819. Southern France. Crystalline hail. (R21)

X4. 1863. Tiflis, Russia. Crystalline hail. (R21)

X5. June 9, 1869. Tiflis, Russia. "...a complete 'shower of ice cry stals'—not of fragments of ice of indisttnctly crystalline outlines, but of spheroidal crystalloid solide, densely but irregularly set, on the sur faces corresponding to their longitudinal diameter, with limpid regular drystals showing varlous combinallona of forms belonging to the tri- and monuaxial Systems------a peculiaríty which



hailstones formed oí crystalline mi ses (X5J



U seems, has not yet been observed, or at Ieast published. The forms characteristic of calcareous spar and of specular oxide of iron prevailed, especially the scalenohedron. combined with rhombic planes, in crystals 15 to 20 millims. in length. Other crystals exhibit the prísm, combined with obtuse rhombohedra, and with the terminal plañe
perpendicular to the principal axis--------How could indeed the formation of such crystalline aggregation6, as regular as those of the cal- careous spars of Andreasberg. be possible in the midst of the tumult generally sup- poBed to be necessarily connected wúth the formation of hall?" (RIO, R12, R21, R28)

X6. June 21, 1809. Bely-Klutch, Russía. (R21)

X7. 1876. Italy. (R21)

Xb. June 29, 1879. Bale, Ruasia. Lenticular central mase with pyramidal crystals set around the clrcumference. (R17, R21)

Xíi. October 1, 1889. Philadelphia, Penn- sylvanía. "On some of the stones, thoughnot on the majority of them, well marked crystals of clear transparent ice projected from their outer surfaces for distances ranging from one eighlh to a quarter of an ínch. These crystals, as well as I could observe Irom the evanescent nature of the material, were hexagonal prisms with clearly cut terminal facets. They resembled the projecting crystals that form so common a lining ıD geodic masses, in which they have formed by gradual crystallzation from the mother-liquor. They differed, however, of course, in being on the outer surface of the spheruies. "(R29)

XI0. January 2f>, 1940. Sheffield, England. "¸. .a sudden ’deluge* of sharply edged hard transparent crystals cf clear ice. Unaccom- panied by any other form of precipitation thev fell profusely from a sk> generally over- cast to form on the ground a thick layer of dr> ice gralns that were remarkable for the size-----some 3-4 mm. in length-------to wThich each bad grnwn as well-developed single hexagonal prisms with basal planes and show- ing sharply cut crystal faces." (R51)

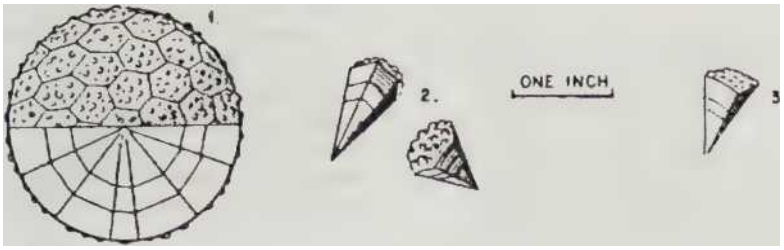
XI1. No date given. Clermont, France. Hexagonal prisms terminating in six- sided pyramids. (R5)

X12. July 4, 1819. Baconniere, France. "During ten years. M. Delcross had observed that bail consisted of spherical pyramids or fragments of spheres, which had been broken by some explosión, and the cleavages of which always passed through the centre of the sphere. He frequently looked in vainfor the original sphere, but never observed it until the 4th July 1819, during the dreadful hailstorm at Baconniere. Some of the spheres were fifteen inches in circumfer- ence. " (R2)

X13. June 27, 1823. Aberdeen, Scotland. "The regularity in the shape of the hail- stones, and their hard and peculiar consis- tence, seemed to entitle them to some no- tice. They were inciuded, almost univer- sally, each by five sides or surfaces, four plañe, constituting the sides of an irregular pyramid, and one spherical in place of a base. The length of the longest line did not exceed 1/2 inch in any instance that I observed; but as the hail-stones dissolved very fast, and as they were indeed, for the most part, rounded in the angles before I found them, it is probable they had been larger ai first. 1 however examined them the moment they fell. The spherical sur- face appeared, to the deptb of 1/20 to l/30th of an ineh, to be solid, as it was transparent, The rest of the bailstone was opaque, conslsting of crystals or minute columnar forms, perpendicular to the spherical sur- face." (R3)

X14. August 2C, 1834. Padua, Italy. Tetra- hedrons. (R4) Same as X2 ?

X15, March 31, 187b. Leamington, England. "The hail fell from a thick heavynim- bus, Corning from the S. E., wfaile the sun in the W. was not obscured. It fell thickly for about 20 minutes, with much noise, both in the air, and from the roofs and trees, and splashed the river considerably on the surface. Everybody ran into shelter, as we!) they might, considering the si2e ofthe stones, which were as big as pebbles, angular, and pointed. i'hoj appeared to be shaped like pyramids, with polnts, and con- vexbases, studded with tubercules, and had plain sides, either square, pentagonal. rr



Teirahedrat hailstones and posluialed parent sphere (X15)

hexagonal. They would have profaably belonged to complete spheres, when their sides were adjusted together, and which would havebeen about 1 1/4 in. in dlameter. and these seg- ments were, therefore, about 1/2 in. long. They were of crystalline ice, with concen- tríc bands, and probably the perfect pyra- mids weighed from 10 to 20 grains, and, as 24 might be estimated to make up a sphere, this, at the least, might have been hall an ounce in weight, and ai the most about one uunce As they were tuberculated on the convex bases, the whole sphere would have looked verv much like a raspberry, or an oxalate of lime cálculos. These spheres of ice must have burst, or become split up into segments somewhere in the fall through the air, as none were actuaíly found perfect on the grass in the gardens." ÍR15)

X16. November 23, 1888. Edinburgh, Seot- land. Pyramids with four fíat sides and a convex base. The ice was transparent with numerous liquid-filled eavities. (R26)

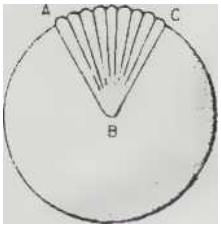
XI7. October 13, 1919. Chiltern, England. . .a dense mass of hail literally swooped out of the squall cloud. I was out al the time and avoided immediately seeking shelter in order to examine the shape and texture of the hailstones. I found that all those which 1 caught on the sleeve of my overcoat were white and opaque, and in shape tetrahedral, showing four triangular faces roughly between 1/8 and 1/4 of an inch in length from base to vertex." (R45) Note that these are true tetra- hedrons as opposed to the pyramids with rounded bases typifted by XI5.

X13. June 3958. Fort Collins, Colorado. "In a recent hailstorm on the campus of Colorado State University al Fort Collins, the writer observed a number of hailstones having the shape of a triangular pyramid. The stones were formed from layers oí ice of varying opacity in concentric layers about the tip of the pyramid. The measured dimensions of the largest stones are given on the accompa- nying sketch. (See íllustratiun of X15 for configuration.) The shape of the stoneindi- cated that about 1/4 inch had melted from the tip of the pyramid before measurements were made. The smooth sides of the pyramid indicated that the stone probably was fractured from a sphere that initially was about 3 1/2 Lnc-hes in diameter. " (R57)

X19. April 24, 1887. Marlborough College, England. "On April 24. about 12.30, while walking between Melrose and Kelso, a friend and myself were overtaken by a sudden and very violent hailstorm, accompanied by thun- der. The violent burst lasted about two minutes, in which time the ground was complete- ly covered with large hailstones rather more than half an inch long. 1 say 'long' advisedly, for all the specimenB I examlned wereconical, and were all of them formed the same way.

The potntB had all the appearance of snow, beíng softer than the maín bulk of the 'stones.' These snow portions occupied about one-third oí the whole length, being white and non-trans- parent. The main portions of the hailstones were hard and ice-like, stranded lengthwise
with from forty to fifty fibres of ice---------each fibre curved separately at the top-------and to gether forming a curved surface, as of a sphere having the snow point for íts centre.

Od melting, the pointod part became trans- lucent, while the other part became more opaque than at First, strands often remainlng for a time, partly separated and curvingout- wards, as though they had been freed from compression in their lower extremi- ties. The above appearances might admit of the hypothesis that these hailstones were fragments of radiated crystalline spheres, but one would expect in that case to fínd pyr- amidal rather than conical shapes, or al least to find some shaped so as to comple- ment the conos. " (R23)



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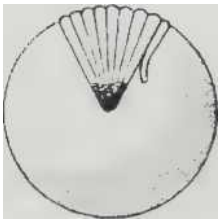


Corneal hailstones made of ice hbers (XI9)

X20. June 7, 1902. Cheltenham, England. "Al flrst the hailstones were more or less round and llke small crystallised raspberries: but during the latter and main part of the shower they were in the form of wedges or small cones, somewhat varíed in shape. Many of these hailstones were about three-quartere ot an iaeh in beight and measured about half an mch across. Mr. Swordy suggests that these were only conic sectional parts of what had been much larger hailstones. To test this view he put some selected ice cones in a circle and added two more layers upon the flrst circle and a key wedge or cone at the top- By this arrangement he obtained half an iceball, consisting of fifteen sections. The hailstones when flrst formed may therefore have been about the size of 'pmg-pra^g' balls, about an inch and a half or two inches in diameter." (R41)

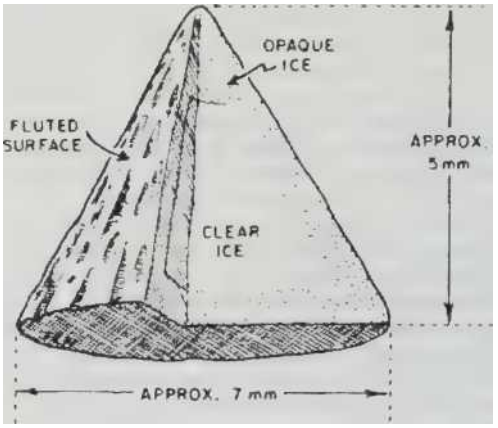
X21. May 1907. Northern Ireiand. Conical hall with rounded bases. (R42) The possi- bility exists that conical hailstones may be pyramids with the edges melted down. (WRC)

X22. May 8, 1910. Epsom, England. Conical hall. (R43)

X23. January 17, 1933. Hastings, England. Cones with round bases about 1/4 inch long. iR50)

X24. February 10. 1945. Uxbridge, England. Conical hail 25-30 mn¡ in height; base, 25 mm in diameter. ÍR54)

X25. April 3. 1968. England. "Among the hailstones of normal character (i.e. roughly spherical) there occurred a fairh large pro-portíon of stones which had the conical appear-ance shown in the díagram below. These



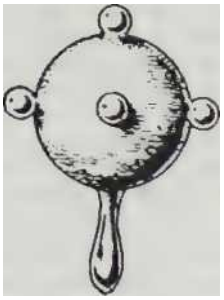
Cortical hailstones with flufed s¡des (X25)

stones had a distinctly fluted outer surface with edges running from base to apex. The stones were Soft and easily sliced with a sharp penknífe. The central core, shaped like a truncated cone, was of clear ice, the outer layer was opaque. The largest c<f the stones observed had the dimensions shown in the diagram but the shape was retained down to sizes of 2-3 mm. " (R59)

X26. April 11, 1878. Cantón, China. Hail-stones shaped like starfish. As large as pigeon eggs. (R16)

X27. December 1, 1878. Plains ol Troy, Turkey. Roundish hailstones with many sharp projections. <R18)

X28. August 21, 1880. Partenkirschen, Ger-many. There had been little or no rain and no visible lightning, and the hailstones Fell at íntervals and about six feet apart. There were very few of them, my family pickíng up twenty in a space occupied by a full-sized lawn tennis court. My son made a sketch of the ir shape and size, which I endose. The greater part were of the 'tadpole' shape and were clear as glass, perfectly round, the five knobs being at equal distance from one another. The fíat stones had more or less a



*Mansiones with **A**nob like appendages (X28)*

sligbt nucleus of snow in the convex portion of the stone. My wife and three daughters, and two ladies staying with us, say that the stones looked just like a lady's hand looking glass, with a knob al the top and on either side for ornament. More than twenty, per- haps thirty, were picked up of this shape. " (R19)

X29. July 1881. Partenkirehén, Germany. Hailstones like those of X2S again fell in this location, but with a greater variety of odd shapes, Including mushroom-like stones. (R20)

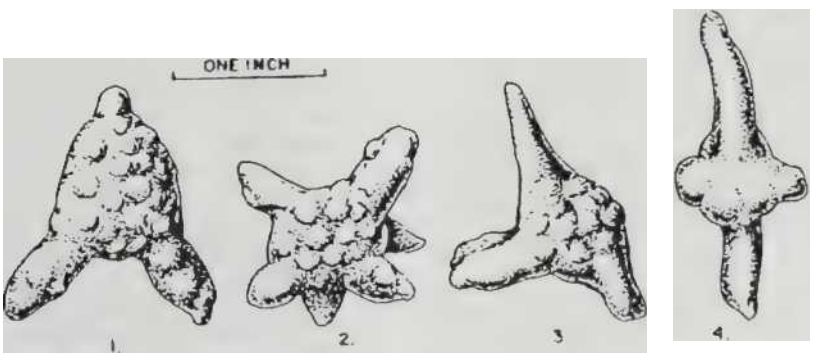
X3Q. August 22, 1893. Welton-le-Wold, Eng- land. A violent hailstorm with large stones bearing irregular projections, as shown in the illustration. (R34)

X31. May 17, 1894. Cleveland, Ohio. Large hailstones, some the síze of goose eggs. Shapes varied from spheroidal, to discoidal, to exceedingly irregular. Some of the stones with a knobby or berry-líke surface were sectioned and found to be formed about a single nucleus rather theD being aggregations of smaller stones. (R31)

X32. February 25, 1900. Harbertsdale, Cape Colony, South Africa. Round hail with spikes, like a hedgehog rolled up in a bail. (R38)

X33. June 21, 1918. King Island, Tasmanía, Australia. "The hailstones were like star- fish, i. e. with a roughly spherical core and fingers out in all directíons, not only onone plañe; more like one of those most usefuJ- lookíng old-time war weapons, spikes pro- truding from a sphere of i ron in all direc- tions mounted on a handle by a short chain! But in the case of the hailstones the spike was much longer, the largeet part of the wbole. One or two I measured were more than three inches across from point topoint, and several were above two inehes in two directions; the centre was comparatively small, from 1/2 in. to 3/4 tn. in dlameter, roughly. They were not heavy, and were clear ice, not opaque as hail usually is, and at the same time each 'stone' appeared tobe an agglomeration of ordinary small haíl- stones." (R44)

X34. July 22, 1925. Plumstead, England. After a hailstorm of greai vlolence. "Iwent ínto the garden and coílected a few speci- mens, examined them, and measured the largest. Its length was 3 1/4 inehes and in width ít was 2 inches. Each hailstone had a central nucleus of white and opaque ¡ce about



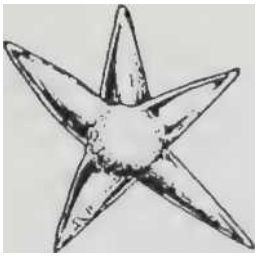
Irregular hailstones that letl in England in 1893 (X30)

the size oí a marble. Round this was a ring of splintery partióles embedded in translu- cent ice. Üutside this was a petal-Uke struc- ture of transparent íce. Une side of the stone was concave, the other convex. Some resembled cracknell bisquits in size and curvature ” (R46)

X35. June 15, 1929. Urbana, illinois. Grotesquely shaped hailstones that seem- ed to be agglomerations of smaller stones.

One measured 6.5 x 2 x 3.5 cm. (R47)

X36. August 6, 1949. Eldoret, Kenya. "The sky becarne very dark and large hailstones fell, but in the shape of stars similar to Ihose of snow crystals in shape (when seen under the microscope). They nearly all measured 11/2 in. in width. They consis- ted of large ice balls the size of a very large pea wlth fíne radiating arms of ice. Some of these landed on their sides and stuckside- ways on in the grass. " (R55)



Iceballs vrith radiating arms 1X36)

X37. August 21, 1963. Indian Ocean. Spheri- cal hailstones with irregular horn-shaped protuberanees 1 L/4 inchs long. (R58)

X38. June 15, 1829. Cazorla, Spain. "... hailstones fell in the form of blocks of ice, some of which had a circumference of 20 ín. and weighed as much as 4 1/2 Ib. Greatdam- age was done, houses being literally crushed beneath the bombardment of ice. (R48) It is the block-like form of the hail that it signifi- cant here and in several of the following examples. See GWP5-X4.

X39. January 14, 1860. Indian Ocean. Dura squall there was a shower of ice con- sisting of large, irregular chunks of solid ice—sume as large as a briek. (R7, R62)

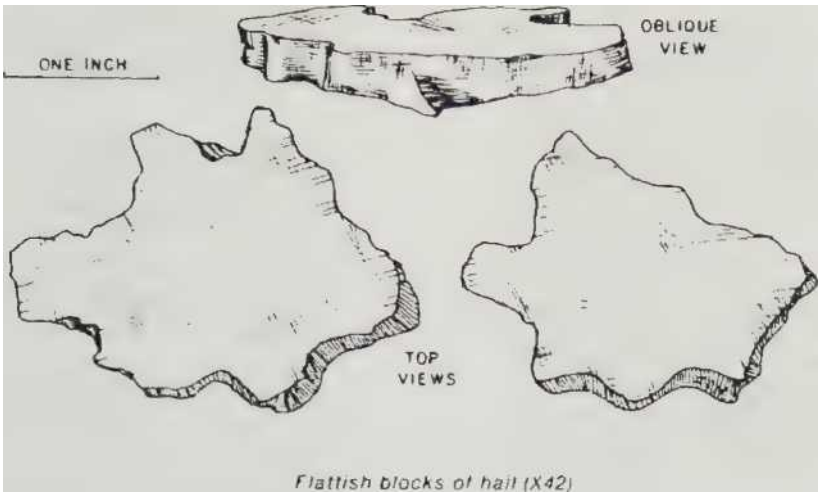
X40. November 15, 1863. South Atlantic Ocean. "Al 6.30 p. m. an immense water- spout formed suddenly in the west, about two miles distant. and bore rapidly down upon the ship. She was steered to the south in the hope of elearing ü. but il approacbed wlthin three ships' lengths and discharged píeces of ice upon our decks, about 2 ínches square (not in balls, but fíat). This was im- mediately followed by a terrible flash of lightning and sharp rattlíng thunder, a deluge of rain, and a furious squall. ” (R35)

X41, June 3, 1894. Eastern Oregon. A tornado was accompanied by unusual hail. "One corresponden! States that the formation was more in the nature of sheets of ice than simple hailstones. The sheets of ice averaged 3 to 4 inches square and from three-fourths of an inch to 1 1/2 inches in thickness. They had a smooth surface and in faliing gavethe impressiun of a vast field or sheet of ice suspended in the atmosphere and suddenly broken into fragments about the size of tbe pairo of the hand. " (R32, R33)

X42. August 10, 1897. Manassas Depot, Virginia. "There was some pretty severe thunder and lightning for a half bour or so, and then carne a heavy shower of rain, dur- ing which there was the most remarkable fall of hail I have ever witnessed. I hurried out in the rain to examine the stones and pícked up several. These were nearly square flat- tish blocks, say from 3/4 to 1 inch in length and breadth, and from 1/4 to 1/2 an inch in thickness. They suggested, by both shape and size, the ordinary 'chocolate caramels,' of the confectioner, " (R36, R37)

X43. July 28, 1979. Hellesdon, Engiand. An unusual fall of large ice flakes measuring 50 x 100 x 3 mm. "Looking out of the front window, we noticed that glistening haii, about the size of large peas to approximately half- penny round, were faliing at about 5 to 7 to the square foot. Then we thought it was 'snowing', so we looked more eloseiy from the open front door and said it must be white rose petáis, about two inches by four inches and about an eighth of an inch thick... and about one per square yard. Then they in- creased ín number to about orn: per square foot, and one landed on the doorslep, and they renched about a palm in size, i.e, four inches round. This size lasted just over a timed minute; then they slowly drífted back to one per square yard, and after a fuil five minutes or slightly longer there were none." (R61)

X44. 1806. Morris County, New Jersey. "The hail stones were gene rally about one íourth or three eighths of an inch thick and of sufficient dimensión in length and breadth



Flattish blocks of hail (X42)

to bidé a shilling, and in many cases a cent, and aJmost every one perfórate*! in the mid- dle as ií they had been held between the fin- gers, tiil the fingers hy iheir warmth had melted away the middlc and had inet. When the perforatiun was not complete, therewas in every case an inclinatlon lo períoration." <R1)

X45. June 14, 1680. Russia. Hailstones pierced with hole from side to side. tR21)

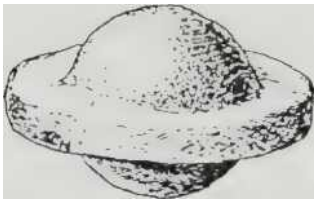
X46. July 12, 1902. Cañada, "Many of the pellets, both small and large, were almost períect spheres, bul not infrequently the large ones took the forra of disks, tilín and transparent in the middle. with thicker edges of snow, reminding one of the sbape of the red blood corpuscles or the fly-wheel of a sewing machine. One large pellet of this kind measured 1.75 inches in diameter and the circular rim waí> one inch tlnck, the middle portion of the disk being transparent." (R40)

X47. August 8, 1901. un the St. Lawrence River. Cylindrical hail, hke pieces of round lead pencils, 8/8 inch long.(R39)

Xi8. May 29, 1944. London, tngland. Hail was initially spherical but changed to double convex lenses. "The climax was, however, reachcd by the sudden appearance of a slab of ice which luckily fell a few yards From where l was standing. This formed one hall *oí* a cylindrical mass slpit along its dlan.eter, which measured 1 3/4 ín. Its thickness lay between 1/4 and 3/8 ín. Ihe central core, of diameter 5/8 in. was of olear transparent ice, the outer annulus being of the opaque variety. ' (U53)

X49. September 12, 1930. Cyprus. Dutten- like hailstones the size uf an English pen- ny. (R49)

X50. June 25, 1888. Guildford, England. Spherical hail with raised rims, looking like the planet Saturn. (R27)



X51. May 29. 1859, Beeston, England. "The principal forms were round, acid-drop shaped, and a small circular stone attached to a larger one, the general proportional sire being as 3 to 1. There were, however, very many closely resembling an appearance of Saturn with his ring, and another preva- lent form veo' [like a fr]>ing P[an with a shorl] handle. Among the more remarkable shapes, one represented a section of an orange; another a cióse representaron of a leg of mut- ton; another a comma; another a sheet of glass, while others were too grotesque for any ptetorial description. " (R6)

X52. June 20, 1870. Northampton, Massa- chusetts. A variety o I hail stone shapes, including starfish types, symmetrical ovoids with rough crowns, and one with spiral layers oí wbite and clear ice nl- ternati ng. (R11. $R1^3$)

X53, No dato or placo. Hall in the shape of exact cubes 7 mm in size. (R22)

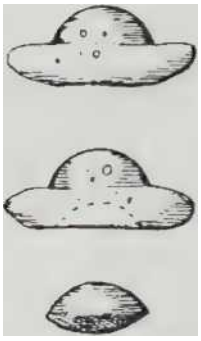
X54. May 20, 1887. Penraaenmawr, Great Britain. Pear-shaped hailstones. (R24)

X55. April 8, 1890. Hampstead Heath, England. "A remarkable shower of soft hail oc- curred hero shortly before 1 p. m. on Tues- da> last (April 8th). The masses of hail (they wpft neither 'stones' ñor 'balls')were of irregular shape, tu some cases half an inch in diameter, and appeared tu be made up of srnall piafes of ice adhering like the potáis of a double marigold. The last form, on melting, was an irregular disc of íce.
A noticeable point was the facility with which the masses adhered on beingbrought ínto contad, so that merely by puttingthem together on a sheet of paper you could got a layer three inches or more in diameter. " (R30)

X56. June 28, 1942. Silver Lake, New Hampshire. ”,. .some of the hail consisted of only a hollou shell 1/16 to 1/8 m. thick, but 3/4 in. across and 1/4 in. thick, evi- dently a hailstono which was still partly 11- quid when it struck, but which had cracked open and let the waUr out. I found one stone that had the unfrozen waLer still in it, for the bubbles moved about as it was tilted. As the hail melted Sume of the stones be- came complete rings of ice. The outer edge of the hail had frozen more than the Inner portions, presumabiy because of the greater flow of air. " (R52)

X57 February S, 1954. Persían Gulf. "The stones fell with suffícient forcé that the brass binnacle cover of the standard com- pass was badly dented. The stones aver- aged about 1 1/2 in. diameter, and it was observed that many were perfectly hemi- spherical in shape, as though split in half, and showing rlnged layers of ice on the fíat surface." (R56)

X58. May 2, 1887. Kingston, Jamaica. "The hailstones were of clear ice, inclosing afew bubbles of air, varying from mere points to bubbles of the size of a split pea. The shape of the stones was singular. Suppose a shal- low and very thick saucer to have a shallow cup. without a handle, inserted in it, and you will have a good idea of the form of the hailstones when unbroken. Many had more or less lost the 'saucer' by violence, while some were entirely without it, presenting the appearance of a double convex leas with faces of dlfferent curvature. " (R25)



Saucer and lens-shaped hailstones 1X58.

X59. May 7, 1862. Headlngley, England. A hailstorm of great violence and remar- kable for the wide variety of hailstone shapes. Two of the more startling forms are illustrated here. fRS, R9)

irregular hail, England. 1862 Many examples of each type fell 1X59)

X60 General observation. The mechan)sin for the formation of conical hail or grau- pel is not well understood, the theories offered having defects. A new theory is presentad. (R6Ü)

X61. Jure 3, 1S73. Nottingham, England. Conical hail the size of peas. (R14)

X62. July 2, 1873. Germany. During a journey up the Rhine. "lleavy hailstorms closed just before reaching Sirasburg Sta- Uon. where the paths appeared strevvnwith cubes of icclikelump-sugar, whieh I gotout and sampled, perfect 'squares. (RG3)

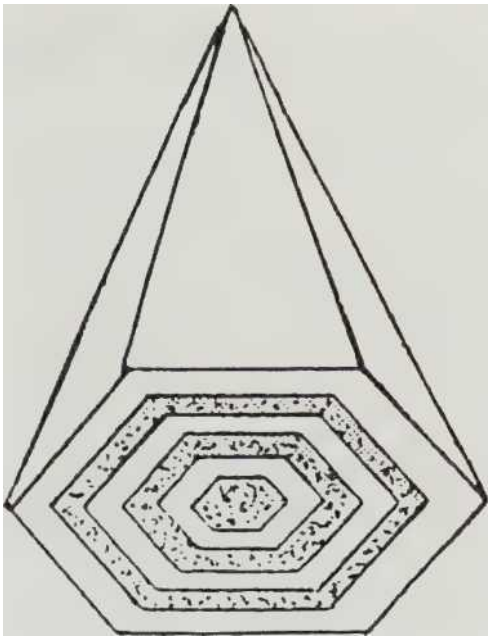
X63. July 1G, 1918. Sur rey, England. ' The lumps were not aggregated sepárate stones. Knobs nearly an **iDch** long were often a bare quarier inch across at the base. Severalhad three such r^und their equator at even dis- tances, with numerous shorter ones allover.
In many cases there must have been fifteen to twenty knobs in ail, or even more. Fur- ther, even the largest lumps had bul one nucleus of opaque íce." <R64)

X63. 1961. Byrd Station. Antárctica. Several very long, very thin, straight hexagonal prisms were photographed under a microscope. Length-to-width retios were greater than 50. One photo shows one of these crystals to be about 1.2 centimeters long. (R63) Thesp and other minute crystals shown in the micro- photographs could also be classified in GWP3 under "diamond dust "

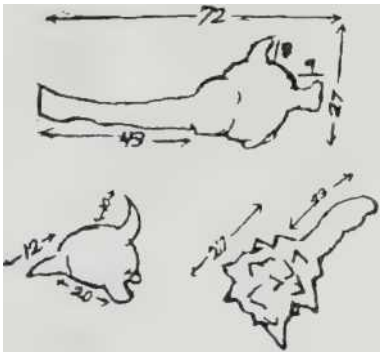
X64. May 20, 1958. Ler.ingrad, ü.S.S.R.
A 3-rninute haílstorm; "...the hailstones were very unusun!. They were about 710 mm in size. and each hailstone wns in the form of a hexagonal pyramid which consisted of six pyramids (one inside the other). Three pvrnoids were of transparent ice, the other three of milk-white ice." (See sketch.) (R66)

X65. July 1, 1982. Nottingham. United Kingdom, A powerful thunderstorm dumped 1.23 inches of rain in 25 minutes. The rain was accompanied by hail that generally measured 3/4-inch across, but a minority of the hailstones were ciga- rette-shaped and about 2 inches long. (R67)

X66. October lf-, 1993. Tulsa, Oklahoma. From a letter from K.L. Partain. "Fun- nel-like phenomena were reportad bv local weathercasters, one of which ap- proachcd within one mile of the witness [K.L.P.] before it lost its vorticitv.



A h ex ag onal-pyr amida! hailstone with nested i re luyers. (See also XJ5) 1X64)



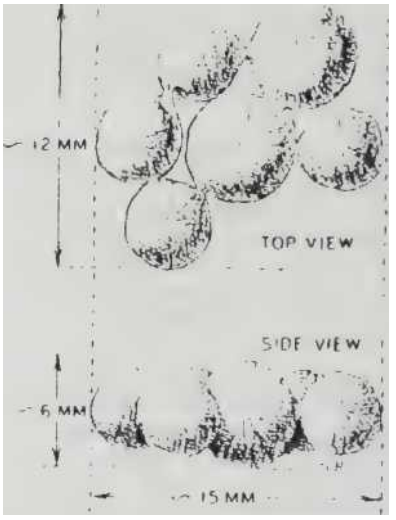
Weirdly shaped hailstones as skelcheü by K L. Portain. Many copies of eoch im-probable species were observed. 1X66)

This was between 5:00-5:15 P.M. and parenthesized the intervai uí anornalous hail. In the target intervai, numerous hail peppered the aren described above. Partain observed shapes which did not con form to spherical and collected several specimens, which he immediately froze. (R68) (See accompanying figure for sume shapes and dimensions.)

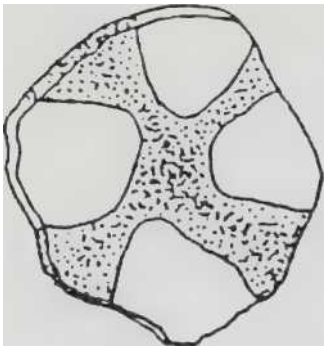
Ol'ten such grotesque hailstones are elosely duplicated in immense quantities —a meteorological factory of the absurd — and we do not Itnow how this produe- tion line operates!

X67. May 17, 1993. Berkshire, United Kingdom. "As the coid front passed over Woodlands St. Mary, West Berkshire (183 meters above sea-level), at 1555 GMT. therc coinmenced a 3-minute dura- tion fall of unusual, flat-plate hailstones, measuring some 12-mm wide hy 2-mm thick, These pistes were smooth and glassy in appearance (íiidicating condi- tions or 'wet' growthj but not perfectly round, takíng on an eccentric, wheel- like structure; with a 'hub' and four- spoke formation of transparent ice, having opaque areas in between. (R69)

It ia most unusual to find water-based precipitation with four-fold symmetry, It is also difficult to imagine a meteorological process that could create millions of these anomalous hailstones.



A fíat, quQsi-hexayonal aggregation of ***severo!*** *spherical hailstones. tXfíS)*



12 mm

A flat-plate hailstone ***with*** *four icy spokes. A* ***deviati'ün*** *from six-fold* ***sym-metry.*** *(X67)*

X68. December 24, 1994. North York- shire, United Kingdom. The following description comes from the British jour- nal: Weather. "The hailstones were roughly spherical in shape, with a día- meter of 4 to 8 mm, and translucent, with a faint, erystalline structure radi- ating from their centres. There were also some agglomerates of two or three stones and, unusually, o few conteined four to as manv as eight stones in an irregular but planar arrangement, with the larger ones tending towards n hexa-gonal conformation and dimensions of approximately 15 x 12 x 6 mm." (R70) That snowflakes may agglomerate in largo pancake-like aggregations has often been observed (GWP2), but this is the first time we have heard of hail-stones being welded together in fíat, hexagonal configurations. What draws the sepárete hailstones together into the same quasi-hexagonal geometry displayed by snowflakes?

X69. Mid 1966. Ecclesfield, United Kingdom. (See "amazing" Ülustration on p. 85.) "This huge tear-drop of ice, weighing four pounds, fell out of the sky and landed on a grass verge near stun- ned commuters at a bus stop in Ecclesfield, near Shefñeld." (R71)

Based on its weight, this "drop" of ice is about 5 inches across. One won- ders where in the sky such a large drop of water could form and remain oloft long enough to freeze solía. The hock- neyed explanation that such ice falls come from leaky aircraft lavatories seems unlikely here! (GWF1)

Unfortunately, one has to consider the possibility of a hoax here'

X70. March 8, 1997. Buckinghamshire, United Kingdom. "An unusually intense fall of hail occurred in the Millón Keynes ares of Buckinghamshire during a sudden early afternoon thunderstorm. The hail- stones were at least 18-mm aeross; the largest probably measured just over 20 mm immediately after the fall. Some of the hail whieh covered the ground was of the 'soft' spring variety; however some hard eonical stones «eeompanied the fall which disrupted road tvafñe in 3 Mile Ash. Some leaves and berries were stripped off trees. Conical hall 10-mm in diameter was also reported from Chal-grove (Oxon)." (R72)

X71. July 31, 1999. Charleston, WV. We quote from a letter from J.B. Dotson. "...on July Jls1 at 4 A.M (EDT) we had an early morning thunderstorm that produced eonicul-shaped hail-—about the size and shape of the 'caramel corn' candy sold around Halloween; or slightly larger and less flattened than the actual corn kernel." (R73)

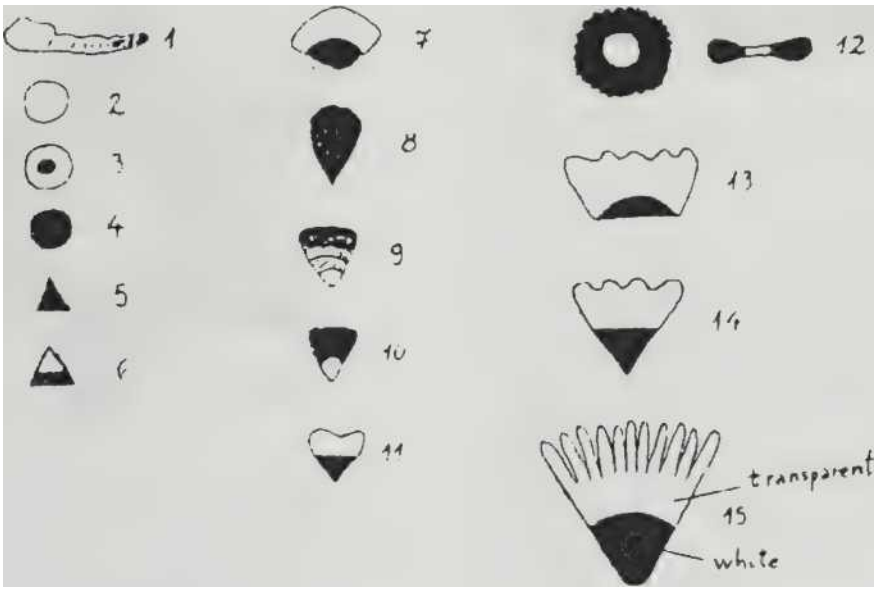
X72. June 29, 1984. Padis Plateau, Romania. This plateau is located ín the Transylvanian Western Carpathians. The weather was pleasantly warm even though the ground was still covered with snow. A. Kosa-Kiss described the approach of a thunderstorm.

"A weak shower of rain followed, and then loose-structured 20-mm-diameter dises of ice. Soon afterwards wliat was to be 30 minutes of 'sky fire' set in. Stone-like pieces of ice streamed to the ground, very heavily and violently.

Some of the hailstones were the size of a nut or plum. Within minutes a white carpet covered the plateau of Padis nt an altitude of 1200 metres (3900 feet) , and the air grew very cool." (R74)

Some of the hail was very oddly shaped. See Kosa-Kiss' appended sketches to appreciate the variety of hailstones that fell in this atorra..

X73. No date. Víales, United Kingdom. A. Mills described in New Scientist a fusillade of hailstones shaped like the



Hailstones skelched by Kola-Kiss. Note especially: the pyrumids, ***5. 6.*** *9 -JJ ; circular hailstones with* ***boles:*** *mui thnse shaped ¡ike badminton shutllecocks. (X72)*

popular ciindy called Hershey kisses.

"During a recent hailstorm in Wales, I was surprised to see that all the hail- stones were eonical. Eaeh one had an apex angle of about 75°, with a fíat or slightly curved base about 4 millimeters ncross. What caused this? Ia this shape common, and is its similarity to an Apollo re-entry capsule coincidental?'' (R75)

How eonical haii (and cónica! snow) form rather frequently and in prodigious quantities and in surprising geometric perfection. How this happens in the mael- stroms of vioJent storms is unknown,

A neatly scuítped contení funis tone (\ike piece of Hershev kiss canríy,[1]) (X73)

X74. June 26, 2001. South Darenth, United Kingdom. A very rare form of hail was reported in Weather by N.
Baker. "At about mídnight a very vio- lent wind carne, gusting to about 20 m s"[1]. There was more lightning. Then 1 heard the clatter of hail against my window 1 looked out at the patio. The hailstones were up to 2 cm in diameter. but there were also chunks of ice 1 cm x 4 ern, whieh must heve been fragrr.ents of larger stones. Some of the fragments seemed to be hollow tubes." (R76)

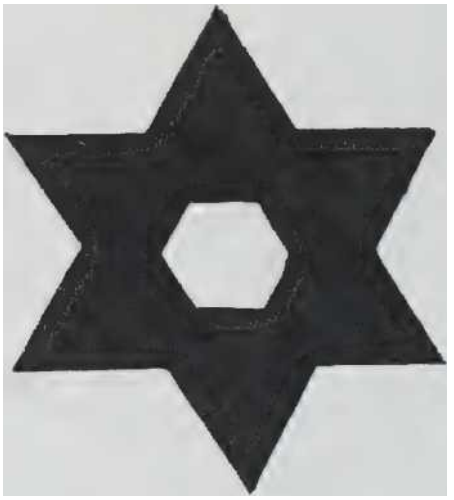
Some ice machines make tubular ice shells but how does Nature do it?

X75. February 25/26, 2004. West Sussex, United Kingdom. V/e have here a real challenge to those who would explain the formation of hailstones. S. Dunlop relates bis experienre as follows:

"During the night of 25/26 February 2004, there was a modérate frost and a slight fall of ice crystals, (A nearby station recorded air and grass minima of -3.5 and -7°C respectively.) Some of these crystals, which had fallen onto the ice of frozert puddles, were observed to have an unusual structure. They took the form of perfect, six-pointed stars about 5-fi mm across and about 1 mm thick. The striking feature was that they had tiny central hexagonal boles about 1.5 mm across." (R77)

S. Dunlop, the observer of the siar- shaped crystals wiíh holes, reminds us that R. Greenler, in hia Rainbows, Halos, and Glories, pictures an ice crvstal hexagonal í;» outline with a star-shaped central hole---the reverse of what Dunlop had seen.

Significantly, Dunlop asks how the deecribed ice crystals can grow outwards in hexagonal geometry wlien they have holes at their centers! Are not central nuclei required to start crystal growth? (R77)



A star-shaped ice *flakc* with he.ragronai *hole (X75)*

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GWP5 Giant Hailstones

Descriptlon. Hailstones weighing more than 1 pound and/or exceeding 4 inches in diameter, these being the approximate limits set by meteorological theories of hail formation. Giant hailstones fall along with smaller hailstones during storms and thus differ from the ice falls and hydrometeors (GWF1), which are usually solitary phenomena and often occur in the ab- sence of storms.

Background. Reports of hailstones the size of marbles, hens' eggs, etc. are numerous. Hail of these dimensions pose no problems in explanation, at least in the matter of size.

Data Evaluation. Several believable reports of hailstones larger than 4 inches and weighing more than a pound have been found in the literature. Such reports are few in number, and in no instance do the dimensions greatly exceed the meteorologists' upper limits for hail.
As in the case of hydrometeors, however, one finds reports of colossal hailstones, which, like fish stories, must be discounted according to age and lócale. Rating for hailstones modestly larger than 4 inches and/or 1 pound: 1.

Anomaly Evaluation. SInce the high-quality reports of giant hailstones claim dimensions not significantly greater than theoretical considerations permit, it seems that slight modifi- cations of theory can explain most believable observations. Rating: 3.

Similar and Related Phenomena. Ice falls and hydrometeors (GWF1); hailstones with anoma- lous shapes (GWP4), some of which approach the acceptable dimensional limits.

Examples of Giant Hailstones

XI. March 1295. Yemen. A greal hail- storm that killed many animáis. One hailstone, which partly buried itself in the ground, was supposedly so large that men could not see over it. This ac- count was reprinted from the Annals of the Resuli Dynasty of Yemen. (R4) Ob- vlously such a story must be placed in the same class as the Indian hydrometeor that was as big as an elephant.(GWFl-Xl) X2. August 31, 1820. London to the Eng- llsh south coast. Pieces of solid ice 6 x 18 inches fell during a hailstorm.

(R6)

X3. April 10, 1822. Bangalore, India. Angular and oval hailstones, as large as pumpkins. Many cattle killed. (R7, R18) X4. June 15, 1829. Cazorla, Spain. Houses literally crushed under blocks of ice weighing up to 4 1/2 pounds. (R8, RIO, Rll) See GWP4-X38.

X5. August 13, 1851. New Hampshire. Masses of ice fell weighing 1 1/2 pounds. (R15)

X6. May 22, 1851. Bangalore, India. More hailstones the size of pumpkins! (R15)

X7. March 28, 1867. Adoni, India. "In Adoní to the north of the talook, at Nukkul- mittah and other villages, the hail is de- scribed as being of the size of cocoa nuts to woodapples, and lying to one foot indepth; in some places destroying the wet and drv crops. In Gooty, at elght p. m. on the 28th, the hail was described as ranging from the size of bullets to limes; some sheep were killed and crops destroyed.....In Anantapur talook the size of the hailstones is apparent- ly incredible. I give, however, the local report, that in a field of the village ofBon- dalavada some of the stones were two- thirds of a cubic yard in size. In the village of Chadula a cubic span, and in other villages of six seers, or three pounds inweight; this last was verified by the Tahsildar. Two men, 2,470 sheep, and eight cattle were killed, and some thatched houses were de- stroyed. " (Rl)

X8. Autumn 1875. Potter, Nebraska. On a Union Pacific train. "The hailstones were simply great chunks of ice, many of them three and four inches in diameter, and of all shapes-----squares, cones, cubes, etc. The first stone that struck the train broke a window, and the flying glass severely in- jured a lady on the face, maklng a deep cut. Five minutes afterward there was not a whole light of glass on the south Bidé of the train, the whole length of it. The Windows in the Pullman cars were of French píate, three eighths of an inch^thick, and double. The hail broke both thicknesses, and tore the curtains to shreds." (R2, R16) The same area was visite<J by another phenome- nal hailstorm in 1928. See below. (X17)

CWP5 GIANT HAILSTONES

X9. May 3, 1877. Texas. Pieces oí ice as large as a man's hand killed thousandsof sheep. (R15)

X10. June 1881. Iowa. During a hailstorm a mass of íce 21 inches in circumference fell. (R15)

Xll. July 12, 1883. Lake Michigan. Ships on the lake northeast of Chicago reported hail the size of goose eggs. One piece, the size of a brick, weighed 2 pounds. (R3)

X12. July 16, 1883. Urbana, Illinois. Many hailstones measuring 12 inches in circum- ference. (R3)

X13. May 1888. India. Hailstones weighing 1 1/2 pounds. (R15)

X14. December 6, 1892. Gray Hill, Texas. "This remarkable hail fell in large lumps, ranging from three to six inches in diameter. I heard of one piece eight inches in diameter, which weighed four pounds. They were, as a rule, spherical in form, but some were somewhat fíat, and nearly all were covered with oval knobs. They fell ín small areas, about two feet apart, while in other places only one would fall in a space twenty feet square. The average under my observation was about one hailstone to every three feet square. A most remarkable fact in connec- tion with these large hailstones is that some of them have partióles of dirt in the center. " <R5)

X15. Suramer 1902. Yuwu, China. An Eng- lish missionary reported a hailstone of ten pounds weight. (R8, Rll)

X16. August 10, 1925. Heidgraben, Germany. A 4 1/2 pound hailstone, 10 inches long, fell through a house roof. (R8)

X17. July 6, 1928. Potter, Nebraska. One hailstone weighed 1 1/2 pounds and was 17 inches in circumference. Fragments of another, when pieced together, made a stone as large as a man's head. (R9, R16)

X18. January 24, 1957. Northwood, England. A hailstone 4 x 5} inches, weighing 13 i ounces fell during a shower of hail. (R17)

X19. April 7, 1961. Persian Gulf, Hailstones estimated to be at least 5 inches in diameter. (R13)

X20. April 20, 1962. Persian Gulf. Hailstones 4 inches in diameter fell on the decks of the s. s. City of Durban. (R14) X21. General observation. Based upon aerodynamic considerations, the upper limit on the size of spherical hailstones Ls 1 1/2 pounds. (R12)

X22. August 1931. Chikiang Provinre, China. A New York Times Ítem. "Hailstones that weighed fifteen pounds and completely demolished the houses of many poor people and badly damaged most of the government buildings are reported from Fuyang, in Chikiang Province. The storm began with a terrifying display of lightning and thunder, followed by heavy rainfall, which soon turned to hail." (R20)

Many such reporte of large hail ema- nate in news Ítems from China. They must be viewed with great caution.

X23. 1843. Mongolia. An excerpt from a travellers' book from the early 1800s by two Lazarist missionaries."Hail is of frequent occurrence in these unhappy distriets, and the dimensions of the hailstones are generally enormous. We have ourselves seen some that weighed twelve pounds. One moment sometimes suffices to extermínate whole flocks. In 1843, during one of these storms, there was heard in the air a sound as of rushing wind, and therewith fell, in a fíeld near a house, a mass of ice larger than an ordinary millstone. It was broken to pieces with hatchets, yet, though the sun burned fiercely. three days elapsed before these pieces entire- ly malted." (R21)

This report could well have been added to GWF1 as a hydrometeor!

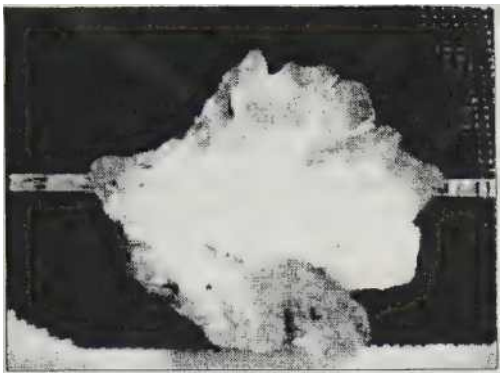
X24. March 1998. Central Louisiana. "Chunks of hail up to 7 inches across slammed onto this Central Louisiana com- munity before dawn Saturday, breaking Windows and battering cars.

"Some of the chunks looked like shrapnel from an exploded mountain of ice; others looked like balls of smaller hailstones fused together." (R22)

Note that most giant hailstones turn out to be aggregates with many smaller hailstones.

X25. September 3, 1970. Coffeyville, KS. A hailstone with a diameter of 5.7 inches; circumference, 17.5 inches. An early U.S. record holder. (R23, R24)

X26. June 22, 2003. Aurora, NE. The currently [2006] "officially" recog- nized largest U.S. hailstone fell on this date. Diameter: 7 inches; circumference, 18.75 inches. (R23, R24)



Photograph of the currently [2006] ***largest*** *recognized U.S. hailstone. It is* ***7*** *inches in diameter. Like most very large hailstones, it is an aggregate of many smaller hailstones, some of which possess crystalline geometry.* *(X26, NOAA photo)*

jleferences

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GWP6 Hail Strew Patterns

Description. The fall of hail in long, parallel strips or geometrical arrays of patches.
Background. After severe hailstorms, farmers surveying their fields often find long strips where the damage is almost total. These linear patterns are called "hailstripes." Hail- streaks are larger-scale patterns of damage, while hailswaths are larger still, being the result of overlapping hailstreaks. A more general term is "hail strewn" or "hail strew" pattern.

Data Evaluation. Hailstripes are rarely mentioned in the meteorologieal literature. Yet, recent aerial surveys and closely spaced arrays of hail-monitoring instruments leave no doubt as to their existence. Rating: 1.

Anomaly Evaulation. Hailstripes are thought to origínate in long, linear storms features termed "hailstrands. " The génesis and precise nature of these hailstrands are unknown, although it seems reasonable that such fine structures of hailstorms will ultimately be en- compassed by current meteorologieal theory. In other words, hailstripes are poorly under- stood details of hailstorms rather than strong anomalies. Rating: 3.

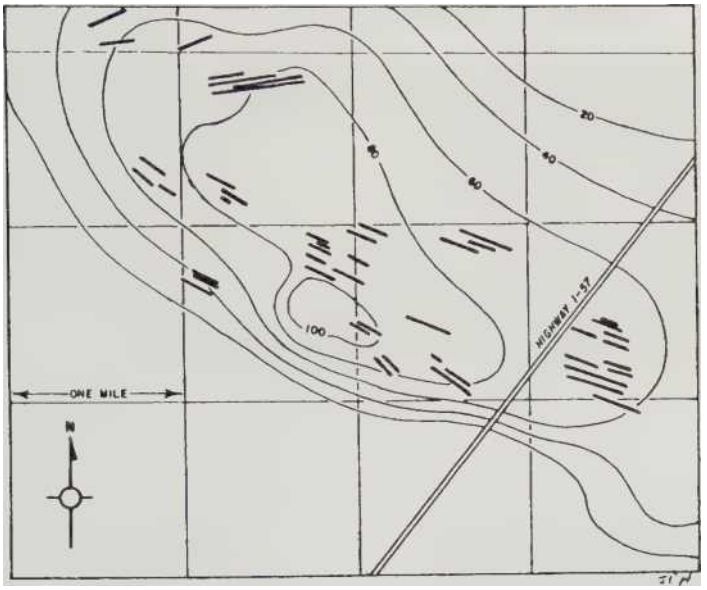
Possible Explanations. Linear hailstorm structures of obscure origin.
Similar and Related Phenomena. Point rainfall (GWP12); whirlwind and tornado tracks.

Examples of Hail Strew Patterns
XI. June 9, 1856. Guilford County, North Carolina. A hailstorm of unusual violence. "The hail fell in lines, a field here and a gar- den there being destroyed, while intermedíate ones were left uninjured. The hail had a strong flavor of turpentine. This is the testi- mony of persons testing it at different and distant localities. " (RI)

X2. July 3, 1863. Clermont-Ferrand, France About 6 P. M. a cloud approached rapidly fronc the west, at a height estimated as 5000 feet.
It resembled a huge net in form, the portion represented by the netting showed violent agi- tation, and soon after the arrival of the cloud there was a heavy hailstorm lasting about five minutes, the hailstones being as large asnuts.
During the fall of the hail there was no wind. The hail caused considerable damage where- ever it fell, and M. Lecoq, who saw the storm and described it in the Comptes Rendus, stated that the damage was limited to small patches, which were surrounded by undamaged zones, forming a network the meshes of which were irregular but roughly 60-100 metres apart.
The distribution of the hail corresponded with the form of the cloud. " (R2, R3)

X3. General observations. Quoting from the Abstract: "A hailstreak is an area of continu- ous hail with temporal coherence and is considerad an entity of hail generated within a thunderstorm. The average hailstreak repre- sents a fast-moving, short-ltved, and rela- tively small phenomenon. Eighty five per cent of all hailstreaks had areas < 16 m¡2 and hail impact energy valúes <0.1 ft-lb ft~2> but areal extremes were 0.9-788 mi^2 and energy extremes sampled were 0.0001-12.6 ft-lb ft^{-2}. A hail-producing system in a 1600 $mi^{¿}$ area normally produced five hailstreaks with an average separation distance of 15 mi. Coid fronts and unstable air mass conditions Ied in the production of hail Systems and hailstreaks, respectively. Hailstreaks produced by different synoptic weather conditions differed considerably. Point durations of hailstreaks averaged 3 min, 43% occurring in the 1500-1900 CDT period. Eighty-five per cent of all hailstones had diameters <1/4 inch and only 1% were 2 1 inch. A 1-ft^2 area in a hailstreak normally experienced 24 hailstones. Hailstreaks occurred in all locations and stages of age of their associated rain cells, but their preferred location was along the major axis and in the mature stage. Normally , a rain cell produced only one hailstreak, although 20% produced four or more. " (R4)

X4. General observations. Hailstripes are microscale hail phenomena that occur on a smaller scale than hailstreaks. "Abstract. Aerial photographs of crop-hail damage areas have revealed a smaller-scale feature of damage patterns than has previously been reported. These features, called 'hail stripes', are long, narrow {15-30 m width) stripes of alternating light and heavy damage. These are believed to be caused by a combi- nation of strong wind and 'hailstrands'. long



Strips heavily damaged by hail in Illinois fields (X4)

string-like substructures of the hailshaft. " (R5)

X5. No date given. France. "The space ra- vaged by hailstorms, often indicates the pre- sence of aerial cúrrente, the devastations being frequently confined to a long and nar- row stríp of country. Sometimes the storm proeeeds in two parallel track8, leavlngthe intervening región entirely uninjured. Thus a hailstorm once commenced in the South of France in the morning, and in a few hours reached Holland. The places desolated for- med two parallel paths from S. W. to N. E.; the length of one was 435 miles; and that of the other 497 miles. The average width of the eastern track was five miles, and thatof the western ten; and upon the space comprised between them, which was twelve miles and a half in breadth, no hail fell, but only aheavy rain." (R6)

X6. July 16, 1918. Surrey, England. "Green- houses were riddled, window panes smashed, trees stripped; vegetables of all kinds destroy- ed. The stones were like walnuts in size, many 1 1/2 inches across. Cereal crops were beaten down, the straw broken in three or more pieces, the green grain beaten out of the ears. The storm passed from south-west to north-east, the damage being confined toa strip of 800 yarda, inside which ’everything growing has been destroyed, whereas the ad- joining land remains unscathed. (R7)

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GWP7 Slowly Falling Hail

Descriptlon. Hailstones that^eem to float gently to the ground. The terminal velocities of some hailstones have been measured as several times less than one would predict from air resistance and hailstone diameter. All examples of slowly falling hail involve large stones; i. e., an inch or more in average diameter.

Data Evaluation. Several qualitative observations plus one estímate of terminal velocity by a trained weather observer. Rating: 2.

Anomaly Evaluation. Slowly falling hail can be explained by appealing to low-altitude updrafts. This phenomenon Ls therefore primarily a curiosity, although the génesis of low-altitude vertical winds is not well-understood. Rating: 3.

Possible Explanation. Low-altitude updrafts slow the falling hailstones.

Similar and Related Phenomena. None.

Examples of Slowly Falling Hail

XI. May 29, 1859. Beeston, England. Grotesquely shaped hailstones more than an inch in diameter fell very gently. (RI)

X2. June 27, 1866. Cricklewood, England. A puzzling aspect of this violent hail- storm was the gentle fall of the larger stones. The big hailstones did less dam- age than the smaller ones. (R2)

X3. Circa 1908. Remiremont, France. The velocities of the hailstones were so slight that they seemed to fall from heights of just a few yards. (R3)

X4. April 24, 1930. Bagdad, Iraq. "The most remarkable features of the hailstorm were the large size and slow terminal velocity of the hailstones and the absence ofdust in their composition.....The total diameter (of an average stone) was one and fiveeighths inch, and in calm air the terminal velocity of hailstones of this size would be nearly 30 miles per hour. The descent of several specimens was actually timed against the wall of a building, and it was found that they fell 40 feet in about three seconds, giving a velocity of only 9 miles per hour. The observer is to be congratulated on his enter- prise in obtaining this measurement, which appears to indícate an upward current ofair of at least 30 m.p.h. at a comparatively low elevation." (R4)

References

Rl. "Extraordinary Hailstorm, " Annual Register, 101:70, 1859. (XI)

R2. "The Storms of June 27th, 1866, " Symons's Monthly Meteorológica! Magazine, 1:43, 1866. (X2)

R3. "More about the Hailstones of Remiremont," English Mechanic, 87:436, 1908. (X3)

R4. "Remarkable Hailstorm in Iraq, " Meteorological Magazlne. 65:143, 1930. (X4)

GWP8 Unusual Inclusions in Hail

Descríption. Anomalous substances found in hailstones. Inclusions of dirt and sand are so common and so easily accounted for by appealing to windblown dust and sandstorms thatthey are not treated in this catalog. Somewhat more curious are inclusions of salt, iron sulfide, radioactivity, and small insects. Ice-encased birds, turtles, etc. must definitely be con- sidered anomalous.

Data Evaluation. Excluding inclusions of terrestrial dust and sand, reports of other sorts of inclusions are generally one-of-a-kind. Age and lack of detail also weaken the case for the more fabulous inclusions. Rating: 3.

Anomaly Evaluation. The chapter on falls (GWE) demonstrated the power of whirlwinds and waterspouts to lLft a great variety of lightweight objects into the atmosphere. This levitating power combined with hail-forming conditions would seem to make all manner of inclusions possible and, in fact, not very anomalous. Rating: 3.

Possible Explanation. Windblown materials serve as hailstone nuclei.
Similar and Related Phenomena. All falls (GWF).

Examples of Unusual Inclusions in Hail

XI. August 26, 1834. Padua, Italy. "... hailstones with nuclei of a dark grey colour. These nuclei, examined by Cozari, consis- ted of grains of different sizes, the largest of which could be attracted by the magnet, and were found to be composed of iron and nickel. The identity of this matter with that of aerolites can scarcely be open to doubt. An analogous observation has been made at Stockholm by Nordenskiold, who proved the presence of little dark grains of metallic iron in some hailstones. " (R4)

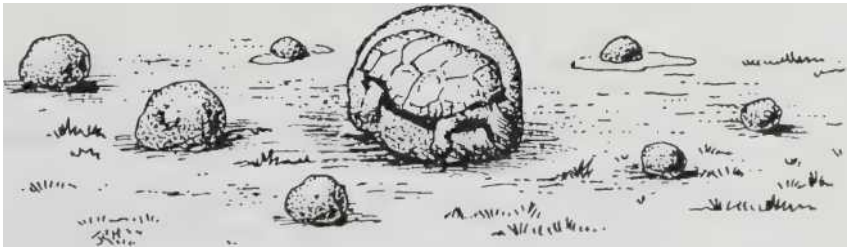
X2. June 1842. Nismes, France. The peculiar taste of some hail led to an analysis that revealed the presence of nitric acid. (RI)

X3. 1871. Zurich, Switzerland. Hailstones with salty taste fell. Crystals of salt found inside. (R2,R3)

X4. May 11, 1894. Vicksburg, Mississippi.

"During a severe hailstorm at Vicksburg on the afternoon of Friday, May 11, a remark- ably large hailstone was found to have a solid nucleus, consisting of a piece of alabaster from one-half to three-quarters of an inch. During the same storm at Bovina, 8 miles east of Vicksburg, a gopher turtle, 6 by 8 inches, and entirely encased in ice, fell with the hail." (R5, R6)

X5. May 26, 1953. Washington, D. C. Fol- lowing a report of radioactive hailstones in the Washington area. "During the subsequent few days, we obtained a number of the hailstones, which because of their unusual size many people had collected and stored. The average beta activity of eleven of the melted hailstones was 1.4 x 10“ curie per milli- liter. Radiochemical analysis of 41 hailstones gave the characteristic isotopic dis- tribution of a young fission product conglom- eration. All hailstones showed the familiar concentric layer formation and most were



10 INCHES

Gopher turtle encased In ¡ce falls in Mississippi hailstorm (X4)

roughly spherical in shape.....It is clear from our measurements, that the centers of the hailstones contained significantly more radioactivity than the outside layers. There- fore it seems probable that these hailstones were formed in a región of relatively high fission product concentration. ” (R7) Atmo- spheric nuclear tests are to be suspected here.

X6. June 14, 1975. Norman, Oklahoma.
A small insect (a chalcid) was found in the center of a 3-centimeter hailstones. The authors also refer to birds encased in ice being observed in the past, but no specific reference was given. (R8)

X7. No date or place given. Hailstones re- ported containing small crystals of "sul- phuret of iron. " (R2, R3)

X8. June 16, 1882. Dubuque, lowa.
A severe hailstorm that produced hailstones weighing almost two pounds; some measuring 17 inches in circum- ference. "They exhibited diverse and peculiar formations, some being covered with knobs and icicles half an inch in length; others were surrounded by rings of different colored ice with gravel and blades of grass imbedded within them. The foreman of the Novelty Iron Works, of this city, states that in two large hailstones, melted by him, were found two small living frogs." (R9)

References

Rl. Ducres, M.; "Observations on an Acid Rain, " American Journal of Science, 2:1:112, 1846. (X2)

R2. "Salt and Iron Hail," Scientific American, 26:128, 1872. (X3, X7)

R3. Nature, 5:211, 1872. (X3, X7)

R4. Schwedoff, Theodore; "On the Originof Hail," Symons's Monthly Meteorológica! Magazine, 17:146, 1882. (XI)

R5. "Remarkable Hail, " Monthly Weather Review, 22:215, 1894. (X4)

R6. "Enormous Hailstones, " Symons's Monthly Meteorological Magazine, 29: 151, 1894. (X4)

R7. Blifford, I. H., Jr., et al; "On Radio- active Hailstones, " American Meteorological Society, Bulletin, 38:139, 1957. <X5) " "

R8. Knight, Nancy C. , and Knight, Charles A.; "Some Observations on Foreign Material in Hailstones, " American Meteorological Society, Bulletin, 59:282, 1978. <X6)

R9. Anonymous; "Hail," Monthly Weather Review, 10:14, June 1882. (X8)

GWP9 Explosive Hail

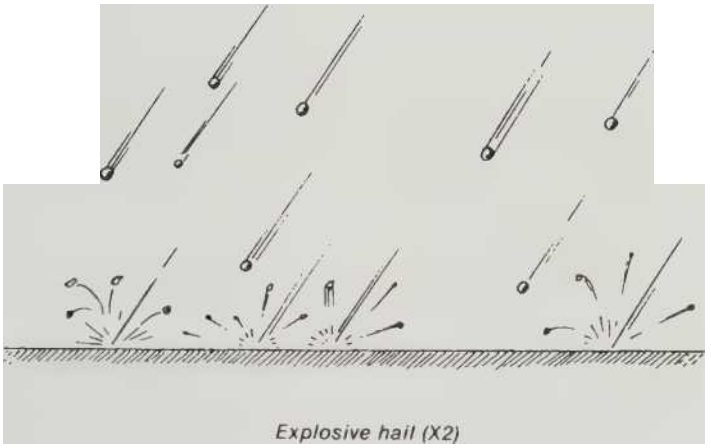
Description. Hail that fragments with pistol-like reports when impacting a hard surface. The fragments fly energetically in all directions.

Data Evaluation. Only two descriptions from the same observer, one of which is presented in good detail. Rating: 2.

Anomaly Evaluation. Explosive hail probably derives its energy from internal stresses accumulated inside the hailstone. The existence of a reasonable explanation for this pheno- menon relegates it to the curiosity category. Rating: 3.

Possible Explanation. Internal stresses due to phase and temperature changes.

Similar and Related Phenomena. The shattering of ice cubes when dropped in warm fluids.



Explosive hail (X2)

Examples of Exploding Hail

XI. Circa 1894. Lexington, Virginia. Hail- stones fragmented upon impact with the ground and rebounded. (RI)

X2. November 11, 1911. Columbia, Missouri. "The morning had been unseasonably warm; about noon there were the usual sounds of a coming thunderstorm-------heavy cumulo-nimbus clouds with a gusty wind-------- which began about 2.30 p. m. with a slight shower of heavy raindrops; shortly after- wards there were two or three flashes of lightning and thunder, followed by a fall of large hailstones, which on coming in con- tact with the Windows or walls or pavement in many instances exploded with a Sharp re- port, so loud as to be mistaken for breaking window panes or a pistol shot. As the hail fell, the fragmente sprang up from the ground and flew in all directions, looking like amass of 'popping corn' on a large scale. The fall lasted two or three minutes, about half the hailstones being shattered, the ground in some places being nearly covered whitewith stones and fragments. Of the unbroken stones, seventy were gathered. They weighed roughly 225 grams. A few were ellipsoidal, the longest axis about 25 mm. in length; most of them, however, were nearly spheri- cal, and somewhat smaller, from 15 to 20 mm. in diameter. Practically all of them contained a nucleus. In a few of the stones the nucleus was porcelain-like, raspberry- shaped, surrounded by almost colourless spherical layers of ice, for about five- sev- enths of the diameter, and then a Shell of porcelain-like, snowy ice. A fair proportion of the stones showed, in addítion to the spherical, a radíate structure, which was very apparent as the stones melted in a fíat dish, showing the eross section with great dis- tinetness." (RI)

References

RI. Brown, W. G.; "Explosive Hail, " Nature, 88:350, 1912. (XI, X2)

GWP10 Colored Precipitaron

Description. Rain, snow, or hail colored blue, green, and any other color except red, yellow, brown, gray, and black. The omitted colora are so common in pre- cipitation and so easy-to-explain that they are not even considered catalogable as curiosities.

An exception is made for the still-mysterious red rains of Kerala, India, that fell over a 2-month period in 2001.

Background. Yellow precípitation is classified with the so-called "sulphur falls" (GWF3), which almost always turn out to be pollen falls. It should be recognized, however, that some yellow rain and hail may be the result of yellowish dust and sand being mixed with the pre- cipitation. Black, brown, and gray precípitation is very common. The contaminating sub- slancés aré usuálly industrial pollutants and ash and soot from distant forest fires. (R2) Many of the "dark days" (GWD), particularly those in North America, have been accompanied by black rain. Throughout history, red or "blood" rains have been viewed with utmost concern by the superstitious. The coloring matter in blood rains inevitably turas out to be reddish dust and organic matter. (RI) The red precípitation of Europe seems to origínate mostly in African dust blown north and is probably linked to the Cape Verde dust fogs (GWD4).

Deposits of red snow have often been observed in the polar regions; for example, the famed Crimson Cliffs of Greenland, described by Captain John Scott early in the Nineteenth Century. Such curious sights are due not to colored precípitation but rather infestation by organic matter. (R4)

Data Evaluation. The accounts of blue and green precípitation are rare and lack scientifíc attention in the journals. Rating: 3.

On the other hand, the red rains of Kerala are well-documented and have been subjected to laboratory studies. Rating: 2.

Anomaly Evaluation. Like the polar red snows, blue and green precipitation probably owe their hues to entrained organic matter, although scientists have not yet deigned to analyze thero. It is doubtful that there is anything more here than mundano curiosities. Rating: 3.

The red rains of Kerala, however, are more puzzling being almost certainly the carriers of yet-to-be-identified biological cells. The Kerala rains even evoke the oíd hypothesis of panspermia. Rating: 2.

Possible Explanations. Contamination by organic matter or industrial pollutants.
In the case of blue snow, one cannot rule out an optical origin, say, the scat- tering of sunlight by snow partióles.

As for Kerala's red rains, it seems likely at present that some terrestrial algae were somehow swept up into the rainstorms.

Similar and Related Phenomena. Dark days and their accompanying sooty rains (GWD1); colored icebergs (ESP3 in our Anomalies in Geology); sulphur/pollen falls (GWF3); blue-green hydroroeteors originating from leaky aircraft lavatories (GWF1).

Examples of Colored Precipltatiop

XI. Permanent feature. Spitzbergen. "When the French meteorologista, Martin and Bra- vais, traversed a field of snow at Spitzbergen, in 1838, it appeared of a green hue, wherever it was pressed by the foot. The coloring mat- ter seemed to reside just below the surface, which was brilliantly white. Upon another excursión, the first observer beheld green partióles spread like dust over the snow, and upon the sides of the field." (R3) Green snow in Arctic said to derive from minute organisms. "(R4)

X2. March 1, 1934. Mount Washington, New Hampshire. Holes dug in newly fallen snow were promptly filled with deep blue light. Sky obscured by dense fog, pre- cluding reflection from blue sky. (R5)

X3. April 12, 1934. New Hampshire. Same effect as in X2. (R5)

X4. January 1955. Western New York State. Bluish snow reported in many towns. (R6)

X5. March 26, 1948. Dayton, Ohio.
A fall of green rain. "During a spring shower, residents of the eastern part of the city were drenched with it. It discolored umbrellas, clothing and left a greenish tint on white-painted homes."

The green tints were soon washed away. Green pollen and/or algae caught up in the rain by wind were suggested causes. (R7)

X6. 2002. Sangrampur, India. "A sticky green rain showered a town in India last week. There were scenes of consterna- tion in Sangrampur north of Calcutta, as it left clothes and buildings stained."

In the referenced article, this green rain, as well as several uncataloged yel- low rains, was [surpringly] attributed to the mass defecation of swarms of bees overhead. An action, according to scientists, promoted by the bees' over- heating and stress! (R8)

The descriptions of several other similar fluid releases by bees in the literature give these easy-to-dismiss anecdotes some validity!

X7. July 25, 2001 and following two months. Kerala, India. Ordinarily, we dismiss red rains and snows as due to the nonanomalouB inclusión of reddish dust, pollen, and other terrestrial organic matter. However, the 2001 red rains of Kerala, India, are more myster- ious and certainly more controversy- evoking. We now record the facts avail-able on Kerala's red rains and some of the scientific discussion that has fol- lowed.

The red rains of Kerala seem to have been water suspensions of tiny, red cell-like objects with virtually no dust included. The Kerala rains were inter- mittent for two months over a wide area of Bouthwestern India. Fort's "blood rains," which he extracted from the oíd journals preserved in the British Museum seem to have come to life again in today's India.

G. Louis and A.S. Kumar, Mahatma Gandhi University, have examined the abundant reports emanating from these rains and prepared a paper for the journal Astrophysics and Space Science.
We quote from their preprint's abstract.

"A red rain phenomenon occurred in Kerala, India, starting from 25th July 2001, in which the rainwater appeared coloured in various localized places that are spread over a few hundred kilo- meters in Kerala. Máximum cases were reported during the first 10 days and isolated cases were found to occur for about 2 months. The striking red coloura- tion of the rainwater was found to be due to the suspensión of microscopic red particles having the appearance of bio- logical cells. These particles bore no similarity with usual desert dust. An estimated minimum quantity of 50,000 kg of red particles has fallen from the sky through red rain. An analysis of this strange phenomenon further shows that the conventional atmospheric transport processes, like dust storms, etc. cannot explain the phenomenon. The electrón microscopic study of the red particles shows fine cell structure indicating their biological cell-like structure. EDAX analysis shows that the major elemente present in these cell-like particles are carbón and oxygen. Strangely, a test for DNA using Ethidium Bromide dye fluorescence technique indicates absence of DNA in these cells.

"In the context of a suspected link between a meteor airburst event and the red rains, the possibility for the extra- terrestrial origin of these particles from cometary fragments is diBcussed." (R9)

Louis and Kumar venture that the Kerala red-rain inclusions "could" be alien life forms, thereby demonstrating the reality of panspermia; that is, the meteoric propagation of life throughout the universe.

The authors reference a paper by F. Hoyle and N.C. Wickramasinghe, known

proponents of panspermia, a news ítem from Nature (412:670, 2001), and com- raents (mostly negative) from various journals and magazines. But they mention not Charles Fort, the recorder of many other "blood rains," an omission which surpriseth not!

H. Muir, writing for the Science magazine New Scientist summarized the research by Louis and Kumar. (p. 34, March 14, 2006). Readers of Muir's arti- cle suggested several possible sources for the red inclusions in the Kerala rains.

V. Liquori remarked that if a link could be found between the Kerala red rains and meteoric activity, the red particles could be organic particles found in some meteorites. Some of these extra- terrestrial particles form vesicles when interacting with water and then take on the appearance of biological cells. (RIO)

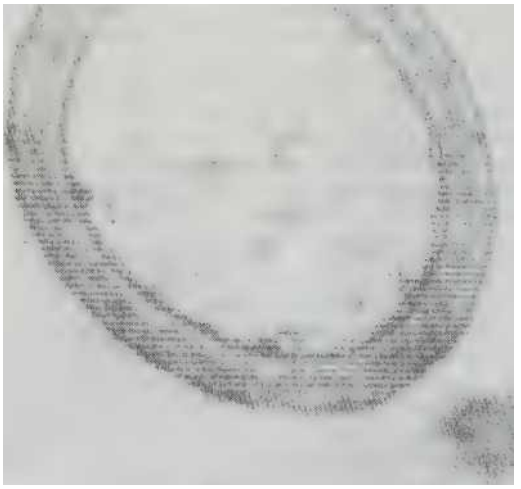
Looking for terrestrial sources, M. Pitt noted that the red-rain inclusions might be liposomes or microcapsules. These are oil bubbles that trap aqueous material. He suggests a mist of such particles might origínate on a vessel burning red oil in the Arabian Sea. Such mists could easily be captured by rain- storms. (RIO)

K. Gardner suggested Rbodophyceae red aigae, which are often seen in bird baths. (RIO)

M. Baker examined the absorption spectrum of the red-rain inclusions, as provided in R9, and saw no evidence of terrestrial hernoglobin. (Rll) The inclusions, therefore, are probably not red- blood cells, which they superfícially resemble.

H. Muir wrote a follow-up article in the April 1, 2006, issue of New Scien- tist. (R12) There, she summarized ana- lyses of the red-rain inclusions obtained from various laboratories as of that date.

- •The red-rain particles are almost certainly biological cells!
- •Hernoglobin is absent, as mentioned above.
- •Chitin is also absent, making it un- likely that the particles are red aigae or fungal spores.
- • Chloroplasts are absent.
- •Contradicting earlier reporte, some DNA is present, although it seems to be of a very unusual nature.
- •The presence of "daughter" cells is puzzling.



A typical "cell" that feU in the 2001 red rains of Kerala, India. Magnification: 25000X. (R9)

- •Just how many of the cells were caught up in such large quantities in rain storms presents another mystery.

The general scientific opinión in mid- 2006 favors a terrestrial origin, perhaps some little- known alga, such as Trente- pholia. (R12)

References

Rl. Judd, J. W.; "The Recent 'Blood Rains, Nature, 63:514, 1901.

R2. Baskerville, Chas., and Welles, H.R.; "Black Rain in North Carolina, " Science. 15:1034, 1902.

R3. Brocklesby, John; Elements of Meteor- ology, New York, 1855. p. 119. (Cr. L. Gearhart) (Xl)

R4. "Colored Snow, " Monthly Weather Review 29:465, 1901. (Xl)

R5. Pagliuca, S., and McKenzie, A. A.; "Blue &ow, " American Meteorológica! Society, Bulletin. 15:114, 1934. (X21

R6. "AEG Checking Blue Snow That Fell in Parts of WNY," Buffalo Evening News, January 27, 1955. (Cr. L. Gearhart) (X3) R7. Anonymous; "Green Rain Hits Day- ton, with Scientists Mystified," New York Times, March 27, 1948. Cr. B. Greenwood. (X5)
R8. Simons, Paul; "Weather Eye," Lon- don Times, June 17, 2002. Cr. A.C.A. Silk. (X6)
R9. Louis, Godfrey, and Kumar, A. Santhosh; "The Red Rain of Kerala and Its Possible Extraterrestrial Ori- gin," Preprint Astrophysics and Space Science, 2006. (X7)
RIO. Liquori, Vinccnzo, et al; "It's Raining Blood," New Scientist, p. 24, March 18, 2006. (X7)
Rll. Baker, Martin, and Banks, Leslie; "Red, Red Rain," New Scientist, p. 25, March 25, 2006. (R7)
R12. Muir, Hazel; "Red Rain Puzzle Is Still Up in the Air," New Scientist, p. 12, April 1, 2006. (X7)

GWP11 Luminous Precipitation

Description. Raindrops, hailstones, and sleet partióles that emit flashes of light and crack- lings sounds when they hit terrestrial surfaces. Some reports refer to electrical "sparks," others to phosphorescent "flashes;" so two different light-emitting mechanisms may be at work.
Data Evaluation. Several good reports by experienced observers from the older literature; but, strangely, none from the past 60 years. Rating: 2.
Anomaly Evaluation. At least three light-emitting mechanisms are possible (see below). Even though no one has investigated this phenomenon, satisfactory explanations seem to be at hand. Rating: 3.
Possible Explanations. Electrical discharges when electrically charged precipitation hits terrestrial objects; triboluminescence (as in crushing sugar cubes); sonoluminescence, in which trapped gasses become incandescent due to sudden, violent pressure changes.
Similar and Related Phenomena. Electrical discharges during snowstorms (GLD5); flashes of light at the bases of waterfalls (GLD14); phosphorescence and sparks when sea ice is broken up by ships. (GLD14)

Ex[arn]ples of Luminous Precipitation
XI. October 28, 1772. France. "...as the Abbe Bertholon was traveling betweenBrig- nai and Lyons, in the midst of a heavy storm, he was surprised at seeing the raindrops and hail- stones emitting jets of light, as they fell upon the metallic parts of his horse's trappings." (R2)
X2. September 22, 1773. Skara Sweden. drops of rain struck fire and sparkled as they touched the ground. (R2)
X3. January 25, 1822. Freyberg, Germany. Sleet struck the earth with flashes of light. (R2)
X4. November 1, 1844. Paris, France. "It was stated to the French Academy of Sciences, that, on the lst November 1844, at haíf-past eight in the evening, during a heavy fall of rain, Dr. Morel-I)eviUe rcmarked, as he was Crossing the court of the College Louis-le-Grand, in Paris, that the drops, on coming in contact with lite ground, emit- ted sparks and tufts (aigrettes) of light, ac- companied by a rustling and crackting noise;

a smell of phosphorus having been immediately afterwards perceptible. The phenomenon was seen three times. M. Duplessy saw at the same hour a remarkable brightness in the northem sky. " (RI)

X5. 1892. Cordova, Spain. "Rain which on touching the ground crackles and emits electric sparks is a very uncommon but not unknown phenomenon. An instance of the kind was recently reported from Cordova, in Spain, by an electrical engineer who witnes- sed the occurrence. The weather had been warm and undisturbed by wind, and soon after dark the sky became overcast by clouds. At about 8 o'clock there carne a flash of lightning, followed by great drops of electrical rain, each one of which, on touching the ground, walls, or trees, gave a faint crack, and emitted a spark of light. The phenomenon continued for several seconds, and ap- parently ceased as soon as the atmosphere was saturated with moisture. " (R3)

X6. July 16, 1918. Surrey, England. "When the hailstones struck the Windows there was a phosphorescent flash of light. " (R4)

X7. January 17, 1817. New England.
On this date a severe snowstorm struck most of New England. It was attended by considerable thunder and lightning. Al- though termed a "luminous snowstorm," the snow itself was not self-luminous. Rather, the phenomenon of St. Elmo's fire was observed on the snowy treetops, fence posts, the roofs of homes, and even people. (R5)

References

RI. "Phosphorescent Rain, " Edinburgh New Philosophical Journal, 39:180, 1845. (X4)
R2. Brocklesby, John; "Electric Rain, Hail, and Snow," Elements of Meteorology, New York, 1855, p. 157. (Cr. L. Gearhart) (X1-X3)
R3. "Sparkling Rain, " Symons's Monthly Meteorological Magazine, 27:171, 1892. (X5)
R4. Clark, J. Edmund; "The Surrey Hail- storm of July 16, 1918, " Royal Meteorológica! Society, Quarterly Journal. 46: 271, 1920. (X6)
R5. Burt, Christopher C.; Extreme Weather, New York, 2004, p. 91.
(X7)

GWP12 Point Precipitation

Description. The concentration of rain, snow, or hail in very small geographical areas.
Many inches of rain may fall on just a few acres to the near exclusión of surrounding terri- tory.

Background. The older meteorological literature describes a number of cloudbursts and "waterspouts" that burst against hillsides, carving deep holes and channels, sometimes in solid rock. Probably these concentrated storms are not really waterspouts because they frequently occur far inland and even in desert-dry conditions.

Data Evaluation. Actual measurements of point rainfall are rare, but subsequent surveys of the physical damage wrought are conclusive that precipitation can indeed be highly concentrated. The excavation of great holes andgullies in resistant terrain has been reported often and is taken as proof of point precipitation. In addition, eyewitnesses tell of funnel- like storm structures over the afflicted areas. Rating: 1.

Anomaly Evaluation. No meteorological explanation has yet been discovered for the formation of intensely concentrated storms in hilly terrain and the subsequent rapid release of huge quantities of precipitation. Point precipitation may be the result of an unrecognized type of storm strueture or some unappreciated ability of certain terrain to focus or capture storms. Rating: 2.

Possible Explanations. Speaking in vague generalities, certain types of topography may "capture" and concéntrate passing storm systems, possibly by augmenting rotary motion much like quasipermanent eddies along a rocky stream bed.

Similar and Related Phenomena. Orographic clouds; the so-called "lake effect" which leads to large snowfalls in the Buffalo area and elsewhere.

Examples of Point Rainfall

XI. May 31, 1682. Oxford, England. Nearly two feet of rain fell in less than a quarter of an hour in a limited area. (R20)

X2. June 9, 1809. London, England. A cas- cade of water and hail poured in a torrent on an area of 200 acres. (R17)

X3. October 25, 1822. Genoa, Italy. About 32 inches of rain fell on a small area (size not specified) within 24 hours. (RI)

X4. July 8, 1847. Tusquitta Mountain, United States. After the fall of a great waterspout. "An intelligent professional gentleman, who visited the locality soon after the storm, de- scribed to me the effects produced. The chasm excavated in the earth, he said, had a depth *oí* several feet, with its sides cut out as vertical as if dug with a spade. The roots of the trees and plants beneath the sur- face, were cut off as squarely as if done with the knife. At the surface, cióse up to the sides of the chasm, nothing seemed to be disturbed. The shrubs and grass, and even the fallen leaves upon the soil, remained unmoved, as though no running water had come into contact with them. This was the condition of things where the waterspout first struck the ground; and as the excavation, at the point of origin, had a width of but a few yards, the whole volume of the descen- ding water, he concluded, must have been concentrated within that space, and continued thus contracted till the contents of the cloud were exhausted. In descending the mountain, along the line of the widening chasm, evi- dences existed that the torrent produced had attained, in places, a depth of sixty feet, up- rooting in its course the largest trees, and removing immense rocks from the gulch cre- ated in its descent to the valley below. " (R3)

X5. 1849. Alpine, Georgia. "A Water Spout, of immense size, the 2d inst., near Alpine, Chattanooga county, Ga. It is said to have made an impression in the earth thirty feet deep, and forty or fifty feet wide, and that it eradicated the largest forest trees, and removed rocks weighing several thousand lbs. " (R2)

X6. May 3, 1849. Bredon Hill, England. An enormous body of water rushed down agully doing considerable damage. "The course of the torrent could easily be traced up the hill for more than **a** mile, to a bar ley field of five acres, the greater part of which was beaten down fíat and hard, as if an enormous **body** of **water** had **been' suddenly poured** out upon it. Beyond thie there were **no** signs of the fall of water to any great amount." (RII)

X7. August 1864. Nevada. "I was travelling from Humboldt mines to Reese rlver. The whole country was dry and parched, as is usual at that season of the year, and the weather was even warmer than common.
About 2 o'clock p. m. I saw what appeared to be a whirlwind. It appeared to be about 25 miles distant, and the spiral column extended from the earth to a very dense cloud, which was nearly as high as the scattered mountains in that vicinity. Soon this column seemed to break, the upper third of it being detached from the rest and bent over to the eastward. I then perceived that this spiral column was not of dust, as I had first sup- posed, but was water. The next day I cros- sed a canon leading from the place where the phenomenon had occurred. Water was still running in it, and there was evidence of a recent flood. Inquiring further, I consulted the Hon. William R. Harrison, a gentleman of scientific attainments who had spent several years in the Humboldt mountains. He told me that such phenomena were not of in- frequent occurrence in the Humboldt mountains, and were called 'cloud-bursts.' He
had witnessed several of them------had once been intheedgeof one, and had once stoodon the top of a mountain and witnessed the ter- rific scene in the canon beneath bim. He says: 'The first sign of them is the sudden galheríng of a small, dense, blaek cloud on the mountain side, about one-third of theway from the top, and generally at the head of a canon. Soon this cloud seems to dash itself to the earth, taking a circular motion. It appeared as if an inverted whirlwind was draw- ing from the cloud immense quantities of water, which is dashed in floods against the mountain side. (R4)

X8. June 14, 1878. Bath, England. "Shortly after five o'clock in the evening the inhabi- tants of the village of Weston, which lies be- tween Kelston Hill and Bath, were startled by a volume of water advancing like a tidal wave along the Kelston Road; in a minute the water was upon them, flooding the houses and laying the main Street four feet deep under water; with such forcé did it come that a stone weighing five hundred-weight was carried several yards, while smaller ones were taken amuch greater distance. It was not known in the village from where the water had come, but it so happened that about five o'clock I was pro- ceedíng to Weston Station by the Midland Rail- way from Bristol to Bath, and when in sight of the Round Hill I was struck by the black- ness and lowness of the clouds in its vicinity. Suddenly there was a flash of lightning, and

immediately after the Hill was enveloped in what appeared to be a storm of rain of un- usual density. On arriving home I was not altogether surprised to find the commotion in the village, and I at once attributed the source of the water to the cloud which I had seen; I therefore made my way in the direc- tion of Kelston Hill. On arriving under the brow of the Hill it was very clear that some- thing more than an ordinary storm had oc- curred. Near the end of a lañe (Northbrook) leading to some fields, the hedge on the right for some yards was lying in the road, bul the field beyond thls point presented only the appearance of an ordinary storm, while the lañe itself was like the bed of a river. To the left was a ñeld of standing grass; for about twelve feet from the hedge the grass remained intact, then for about the same distance it was as though it had been mown down. This torrent, for such it might have been compared to, carne to almost a sudden termination a little above the end of the lañe, but it extended down the Hill till it wasjoined by two others, one of which had carried a hedge away bodily____I gather from specta- tors at Kelston Hill that it began to be cloudy at half-past four in the afternoon; at five there was a rattling clap of thunder, followed by a downpour of rain-----in 'bucket-fulls,' as one expressed it; but all seemed to agree that the greater portion of the water fell under the brow of the hill, where it carne down in several columns." (R5)

X9. October 21, 1881. Little Haldon, Eng- land. A fall of water in the shape of a waterspout. Intense rain in a localized area. (R6)

X10. August 2, 1883. The Ochils, Scotland. A waterspout burst against the Ochils. Much property damage. (R7)

Xll.June 9, 1888. Langtoft, England. See description in X12. (R8, R12)

X12. July 3, 1892. Langtoft, England. "At a place named 'Round Hill,' on Saturday, June 9th, 1888, about noon, a waterspout had tora its way into a slight hollow or combe on the hillside taking a northeasterly course, and formed three large holes in the chalky rubble scattering the stones all around, pro- ducing a flood which immdated the village lower down the valley. These holes, which are roughly circular and connected by adeep trench.... me asur ed from one end to the other about 70 yards, and were from 8 to 9 feet deep in their deepest portions. Several tons of solí, boulders, and gravel were thrown out and carried down the valley by the flood, and the village streets were co- vered with a mixture of these substances. The damage done by that flood of 1888 was, however, insignificant when compared with the one now under discussion. Not more than 20 yards from the site of the former cloudburst, or waterspout, and a little fur- ther to the south, three gutters or trenches have been scooped out of the solid rock, nearly parallel to each other and at right angles to the valley bottom; the direction taken being slightly more easterly than that on the former occasion. From the appearance of the trenches it is highly probable that there were three waterspouts moving abreast simultaneously. Two of the trenches or ravines are 68 yards in length and of great size and depth, and as the hillside here somewhal differs from the adjoining portion, where it consists of loose chalk mixed with soil and is composed of strata of solid rock slightly inclined to the vertical, beneath a thin layer of earth, the forcé exerted in removing the ponderous mass of material, about 180 yards in circumference, must have been very great indeed. The smaller trénch, 15 yards to the left and much shallower, is rather over 50 yards long, but this is discontinued before the summit of the hill is reached, as the gyra- tory power of the tornado had evidently be- come weaker and the spout was presumably drawn up again into the cloud _____The prob able causes that bring about the formation of these waterspouts or cloudbursts in this particular spot may lie in the peculiar character and configuration of the surroun- ding valleys, which all converge to a point south of this place, and have only one out- let to the east» while the north-easterly side upon which the waterspouts impinge is strongly fortified by steep declivities which appear to impede the storms in their path. Here, possibly, the overcharged un- dercurrent of warm air, supplemented by the warm air of the valley (for the afternoon sun had been bright and hot), was suddenly broken into and disturbed by the cool rain and air descending from above, and a series of whirls were formed, which, after developing into waterspouts and con- forming to the laws of tornado motion, moved away in a northeasterly track, and henee carne in contact with the steep hillside, where, finding their paths impeded, they tore huge holes in the hillside. " (R8, R18)

X13. July 2, 1893. Cheviots, England. "A hill in the Cheviots, known as Bloody Bush Edge, was visited by a waterspout or cloud-

burst. The day was oppressive and about 10 A. M. heavy clouds gathered. These broke about 1 P. M. and 'the whole hill and parts of the adjoining hills were covered with a sheet of water'. The peal which forms the surface of the hill was ploughed up to a depth of about five feet, and the rocks beneath laid bare over a space of 3040 acres. The River Breamish rose forty feet in sudden flood, swept away its bridges and destroyed long stretches of roadway. " (R14)

X14. 1898. No place given. "As a boy I saw a small hailfall of about ten to fifteen meters width across a road. We boys ran from the dry side through the hail to the other dry side and back. ” (RIO)

X15. June 18, 1907. Blanchland, England. A waterspout burst, flooding the country- side, breaking up stone walls, anddoing much damage. (R13)

X16. April 26, 1922. Semur, France. A couple driving along a road encountered two "walls" of intense precipitation. (R9)

X17. August 1, 1932. London, England. "It began to rain------heavily at first and then softly. Suddenly torrential rain fell only one hundred yards from where I was stan- ding. The nearest trees in Kensington Gar- dens were almost hidden behind a milkymist of heavy rain. The rain-drops rebounding off the Street created a layer of spray as high as the tops of the wheels of the taxis standing in the Street. Where I was shel- tering, hardly a drop of rain was falling.
The contrast was so striking that I called the attention of an unknown bystander (as though I could not believe my eyes). Then the spray on the ground carne nearer like a wave, and receded. Suddenly it vanished completely, and the trees behind in Kensington Gardens stood out black againstthe sky. It was over." (R15)

X18. August 2, 1966. Greenfield, New Hampshire. "Rain began to fall about 1900 EST, or about an hour before the outbreak of more generalizad showers in the región.
It soon became a downpour, continuing until about 2300 EST, at which time Mr. Stanley went to bed. It was then still raining, but had slackened noticeably. The rain may have stopped by midnight. A remarkable nonvariability of the intense rain was noted by Mr. Stanley. There was very little slackening, even for brief intervals, during the period of heavlest fall» which was from about 1945 to 2215 EST. There was practi- cally no wind. Neither thunder ñor lightning was observad. The noise on the roof was terrific, like that of a continuous waterfall.
A plástic bird feeder mounted on the side of the house was broken by the impact ofsheets of water from the eaves. Looking out the window, Mr. Stanley could see stones and gravel from the roadway, south of the house, being washed away by torrents of water. Up- on rising in the moming, Mr. Stanley noted that the weather had cleared, with a brisk westerly wind. After finding the 5. 75 in. of rain in the gage, he inquired from a neighbor 0.3 mi to the east. He found that the neighbor had but 0.50 in. in his gage. He there- upon examined the countryside for visible effect8. The road washout extended only a few hundred feet. Upon going one-half mile in either direction, no evidence of rain erosión of sand or gravel could be found. South of the house, beginning at the gage which was mounted on a pole, well distant from struc- tures or trees, there stretches a 10-acre field. The knee-high grass therein was beaten down fíat. By afternoon it began to revive. By the following noon it was erect. To the west of the house, a dry-wash brook running bankful at dawn was empty by 0800 EST. Drawing a line around the traces of erosión, one obtains an oval area about a mile north-south and about three fourths of a mile east-west. Within this area, rain varied from the order of 1 in. on the limits to almost 6 in. in the center. Outside this limit, rain is believed to have fallen off sharply to less than one-fourth of an incb* generally within a few thousand feet." (R19)

X19. No date given. Chatham, England. Heavy rain fell in a strip 30 feet wide and three miles long. (R16)

X20. September 2, 1961. The Pennines, United Kingdom. A waterspout "fell," washing away an area of ground 180 yards long by 15-20 yards wide. This caused an avalanche of peat, boulders. and other debris. (R21)

X21. July 17, 1983. Upper Teesdale, United Kingdom. A point rainfall of 104.8 millimeters (over 3 feet) occurred in a 24-hour period resulting in several peat landslides. (K21, R22)

X22. September 15, 2001. Williamson Valley, AZ. A remarkable point hailfall accompanied by 2-4 inches of rain. The hailfall was extremely localized. Its area estimated to be only about the size of a football **field. Residents** a mile away saw no hail at all. The hour long storm swept the hail into piles as high as 8 feet When graders opened up th< affected

road, they heaped up piles 10 feet high. These took a week to melt, even in the usual 90°F daytime heat. (R23)

X23. May 30-31, 1935. Eastern Colorado. An exceptional cloudburst dumped up to 24 inches of rain in 6 hours, based upon readings from three remóte rain gauges. The area inundated was actually fairly extensive and hordly point rainfall. However, the intensity of the rainfall was nearly a world record and highly unusual outside of the tropics. (R24)

X24. July 18, 1942. Southport, PA. "Perhaps the most extraordinary rainfall ever measured in the world occurred in the unlikely location of McKean County, Pennsylvania, in and around the town of Southport.All told, 34.50 inches fell in an 18-hour period of which 34.30 inches fell in 12 hours and 30.70 inches in just 6 hours." (R24)

As of 2004, such intense rainfall has never been recorded elsewhere in the world. (R24)

References

Rl. Forbes, Prof.; "On Excessive Falls of Rain, " Report of the British Association, 1840, pt. 2, p. 43. (X3)

R2. "A Great Waterspout, " Scientific American, 4:414, 1849. (X5)

R3. "Water-Spouts in the Mountains," Scientific American, 14:349, 18G6. (X4)

R4. Young, William J.; "Cloud-Bursts, " Smithsonian Institution Animal Report, 1867, p. 471. (X7)

R5. Wethered, E.; "A Waterspout, " Na- ture, 18:194, 1878. (X8)

R6. Ormered, G. Wareing; "Effects of a Supposed 'Waterspout' on Little Haldon, South Devon, on 21st October, 1881, " Symons's Monthly Meteorológica! Maga- zine, 16:174, 1881. (X9)

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R8. Lovel, John; "Thunderstorm, Cloudburst, and Flood at Langtoft, EastYork- shire, July 3rd, 1892," Royal Meteorological Society, Quarterly Journal, 19:1, 1893. (XI1, X12)

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RIO. Kassner, C.; "Sharply Defined Show- ers," American Meteorological Society, Bulletin, 10:196, 1929. (X14)

Rll, "Cloudburst, " Nature, 125:657, 1930. (X6)

R12. "Waterspout, " Nature, 125:877, 1930. (XI1)

R13. "Waterspout," Nature, 125:913, 1930. (X15)

R14. "Cloudburst in Cheviots, " Nature, 125: 994, 1930. (XI3)

R15. Hinkson, G. A.; "Well-defined Rain Area." Meteorological Magazine, 67:159, 1932. (XI7)

R16. American Meteorological Society, Bulletin, 14:302, 1933. (X19)

R17. Fort, Charles; "The Notes of Charles Fort, " Fortean Society Magazine, 1:14, September 1937. (X2)

R18. Hawke, E.L.; "Rainfall in a 'Cloudburst, Nature, 169:204, 1952. (X12)

R19. Lautzenheiser, R. E., et al; "Remark- able Point Rainfall at Greenfield, N. H., Evening of August 2, 1966, " Monthly Weather Review, 98:164, 1970. (X18)

R20. Meaden, G. T.; "Point Deluge and Tornado at Oxford, May 1682, " Weather, 34:358, 1979. (XI)

R21. Meaden, G.T.; "Point Deluges in the Pennines," Journal of Meteorology (U.K.), 9:47, 1984. (X20, X21)

R22. Carling, P.A.; "Point Deluge in Upper Teesdale," Journal of Meteorology (U.K.), 9:115, 1984. (X21)

R23. Dodder, Joanna; "Holy Hail! Eerie Weather Hits Part of Williamson Valley Area," Prescott (AZ) Daily Courier, October 4, 2001. Cr. P. Huyghe. (X22)

R24. Burt. Christopher C.; Extreme Weather, New York, 2004, pp. 118, 119. (X23, X24)

GWP13 Surplus Ice Crystals in Clouds

Description. The presence in clouds of from 1,000 to 10,000 times more ice crystalsthan can be accounted for by the number of active ice nuclei. The ice nuclei are needed to ini- tiate the crystallizalion of supercooled cloud water.

Data Evaluation. The great discrepancy between ice crystals and ice nuclei is confirmed by actual counts at high altitudes, according to the single discussion of the subject found sofar in the literature. Rating: 2.

Anomaly Evaluation. Modera cloud physics requires that each ice crystal form on an ice nucleus. At present, there seems to be no acceptable theory explaining how all the ice crystals form without corresponding numbers of ice nuclei. Rating: 2.

Possible Explanation. Supercooled water droplets may be carried to high altitudes where adequate populations of nuclei exist by convection. Existing ice crystals may splinter and multiply the number of ice nuclei present.

Similar and Related Phenomena. None.

Examples of Surplus Ice Crystals in Clouds

XI. General observations. Counts of ice crystals in clouds are from 1,000 to 10, 000 times greater than ice nuclei. (RI)

References

RI. "Where Do All the Extra Ice Crystals Come From?" New Scientist, 64:316, 1974. (XI)

GWP14 Decrease of Rainfall with Increasing Altitude

Description. The observation that the quantity of rain collected in rain gauges usually di- miníshes markedly as the height of the gauge above the ground is increased. Apparently, additional rain condenses rather cióse to the ground.

Background. This intriguing observation comes from a very oíd report, but nothing further has been discovered on the subject in later journals and texts. Quite possibly, this pheno- menon is well recognized and explained but has not yet been encountered in our literature searches.

Data Evaluation. Only a single report from 1868 wherein the phenomenon is represented as well-accepted. Rating: 3.

Anomaly Evaluation. According to RI, the condensation of water vapor on coid, falling raindrops cannot explain the facts, but small droplets, invisible to the eye, may be present in sufficient quantity to account for the increased rainfall closer to the ground. If this is true, no anomaly exists. Until such confirmation is found, this phenomenon will be recorded and given a low anomaly rating. Rating: 4.

Possible Explanation. The "sweeping out" of small, invisible droplets of water by falling raindrops.

Similar and Related Phenomena. Precipitation from a cloudless sky (GWP1) may originate in the same population of water droplets that is substantial but nevertheless not visible in cloud form.

Examples of Decrease oí Rain with Increa- sing Altitude

XI. General observations. "One of the most remarkable results of observations made upon rain, has been the discovery that the amount of fall at any place diminishes largely as the rain gauge is raised above the level of the ground. It is not very easy to explain this remarkable fact. The expla- nation offered by Kamtz is, that a falling drop carries with it the temperature of the upper regions of air, and condenses on its surface the aqueous vapour present through- out the lower strata of the atmosphere, as a decanter of coid water does when brought into a room. And of this explanation Pro- fessor Nichol remarks, that 'it is not an hypothesis but a rigorous deduction, giving an account of all the facts as yet ascertained in connection with this subject.' But qnfor- tunately, the explanation, though it undoubt- edly presente a vera causa, will not bear the test of 'quantitative analysis.' Sir John Herschel has gone through the simple cal- culation required to overthrow the theory, and points out, that if we allow the cause the full valué it can possibly have (a valué far exceeding that which can probably be attributed to it) we obtain an effect only one- seventeenth part of what is wanted to account for the phenomenon, " The author next suggests a connection between the phenomenon and the well-known fact of preci- pitation from a clear sky. There are, he says, considerable numbers of small water droplets in the atmosphere, even when the sky seems clear. (Rl)

References

Rl. Proctor, R.A.; "Rain, " English Mechante, 6:357, 1868. (XI)

GWP15 Rain Gushes Associated with Lightning

Description. Sudden gushes of rain or hail that are closely associated in time and space with lightning flashes.

Data Evaluation. Rain gushes have been linked to lightning flashes for over a century. Radar observations of thunderstorms suggest that lightning flashes are followed by the intensifica- tion of radar echoes and ground observation of gushes of precipitation. Some older observations, however, insist that the rain gushes precede the lightning. Rating: 2.

Anomaly Evaluation. There is currently considerable debate as to whether the strong elec- tric fields existing within thunderstorms have any effect on precipitation. Theory seems to say that no connection exists, which is contrary to observation. Rating: 3.

Possible Explanations. Electrostatic fields may help stimulate the condensation of water vapor in the storm clouds. The thunder, too, may affect condensation of raindrops.

Similar and Related Phenomena. Large hydrometeors (GWE1) and the so-called "thunder- stones" (GWF2), both of which are linked to lightning. Hot-air blasts after lightning (GLL12).

Examples of Rain Gushes Associated with Lightning

XI. July 25-26, 1849. England. Observations made during severe thunderstorms. "On this occasion his attention was more parti- cularly directed to the connexion between the electric discharge and the sudden gush of rain that more or less accompanies it, with a view to illustrate the question occur- ring in the Report of the Committee of Phy- sics approved by the President and Council of the Roy al Society, p. 46, 'Is this rain a cause or consequence of the electric discharge?' On the previous day, the 25th, about 3h 50m P. M., during a thunderstorm a sudden gush of heavy rain occurred, which within two seconds, by estimation, was_suc- ceeded by a vivid flash of lightning: the thun- der occurred at a further interval of some seconds. From this it would appear, pro- vided the heavy rain fell over the entire space between the place of observation and that of the electric discharge, that it was not a con- sequence of that discharge, the gush occur- ring at a sensible interval previous thereto. The setting in of the storm of the 26th, about lh 45m P. M., again called the attention of the writer to this point; and several flashes occurred between lh 45m P. M. and 2h 3m P. M. without being preceded by a gush, al- though heavy rain more or less accompanied the discharges, in one or two instances al- simultaneously or immediately afterwards. At length, about 2h 4m P. M., a most violent and very remarkable gush of rain occurred, which was followed within one minute by a most vivid flash of lightning, the thunder succeeding almost instantaneously.....With in a minute or two after this discharge a partial cessation of the heavy rain took place, but sudden gushes occurred at short intervals within the next six or seven minutes; they were, however, unaccompanied by lightning.

___Within ten minutes, however, the storm again burst forth; the lightnings played, the thunder roared, and heavy rain, mingled with hail so thickly that comparatively near ob- jects could scarcely be distinguished, fell in torrents, and the writer observed during the remainder of the storm four or five sudden gushes that were quickly succeeded by lightning. On all these occaslons he is quite cer- tain that the sudden gush of rain preceded the electric discharge." (RI) The order of events here is the reverse of those in the following reporta. (WRC)

X2. General observations. "Abstract. Ob- servations of thunderstorms in New México were made with a vertically-scanning, 3-cm radar on a mountaln top. Prior to a cloud-to-ground lightning discharge nearby, the radar echo overhead was usually quite weak, indicattng low intensities of precipitatlon there. Following the lightning it was observed sometimes that in the región of the cloud where the discharge occurred the radar echo intensity rapidly increased, and shortly there- after a gush of rain or hail fell nearby. These studies confirm earlier radar observations, made by the authors at Grand Bahama Island, B. W. I., in which it was found that lightning is often followed by a rapidly intensifying echo and then by a gush of rain at theground. The increases in radar reflectivlty in small of the cloud following lightning suggest that the electric discharge is influencing the size of the partióles in the cloud. An analysis in- dicates that within 30 seconds after a lightning discharge, the mass of some droplets may increase as much as 100-fold as a re- sult of an electrostatic precipitation effect. " (R2) However, see the following item.

X3. General observation. Calculations suggest that electrostatic forces, such as those in thunderstorms, are not necessary to explain rainfall. (R4)

X4. General observations. "In his book, The Flight of Thvmderbolts, Dr. Schonland States, 'It is a familiar experience to all who live in thundery regions that rain does not usually fall from a thundercloud until at least one lightning flash has taken place.' From observations of many isolated, air-mass thunderstorms over the mountains of New México, we support Dr. Schonland's conclusión. " (R3)

X5. General observations. The following result comes from laboratory studies.
"In general, at temperatures colder than -20°C, hail becomes negatively cbarged, but at warmer temperatures it becomes positively charged. The forma- tion of the lower positive charge center in thunderstorms and the initiation of a lightning flash which precedes the com- monly observed gush of rain on the ground may be explained in terms of this charging process." (R5)

The precipitation (rain or hail) transporta this accumulation of positive charge to the ground, producing an electnc- field excursión plus a gush or rain (or hail).

References

RI. Birt, William Radcliff; "On the Troduc- tion of Lightning by Rain, " Philosophical Magazine, 3:35:161, 1849. (XI)

R2. Moore, C. B., et al; "Gushes of Rain and Hail after Lightning, " Journal of the Atmospheric Sciences, 21:646, 1964. (X2) R3. Moore, C. B.; "Lightning Discharge and Precipitation," Royal Meteorológica! So- ciety, Quarterly Journal, 91:368, 1965.(X4) R4. Brazier-Smith, P. R., et al; "Increased Rates of Rainfall Production in Electrified Clouds, " Royal Meteorologlcal Society, Quarterly Joiirnal, 99:776, 1973. (X3)
R5. Jayaratne, E.R., and Saunders, C.P.R.; "The 'Rain Gush', Lightning, and the Lower Positive Charge Center in Thunderstorms," Journal of Geo- physical Research, 89:11816, 1984. (X5)

GWP16 High Frequency of Wet Weekends along the North American East Coast

Description. Along North America's east coast weekends tend to be wetter than weekdays.

Data Evaluation. Popular belief is supported by satellite-based precipitation estimates. We have, however, only one scientific paper dealing with this phe- nomenon. Rating: 2.

Anomaly Evaluation. The observed wet weekends have been correlated with a weekly cycle in air pollutants along the eastern Atlantic coast. It therefore seems that a reasonable explanation for the phenomenon exists. Rating: 4.

Similar and Related Phenomena. Rainfall correlated with meteor showers (GWS4).

Entry

XI. General observations. A long-time popular belief of residents of the east coast of North America is that weekends are more likely to be wet than the days of the work week. An examination of rainfall data has proven that, indeed, Saturdays received 22% more rain than Mondays. The likely cause: the build- up of atmospheric pollution along the northwestern Atlantic coast during the work week. (R2)

The scientific analysis was carried out at Arizona State University by R.S. Cerveny and R.C. Balling, Jr. Report- ing in Nature, their abstract reads in part: "Three atmospheric monitoring stations record minimum concentrations of ozone and carbón monoxide early in the week, while highest concentrations are observed later in the week. The air- pollution cycle corresponds to observed weekly variability in regional rainfall and tropical cyclones. Specifically, satellite-based precipitation estimates indícate that near-coastal ocean areas receive significantly more precipitation at weekends than on weekdays. (RI)

Not only is the U.S. east coast highly industrialized but the predomínate westerly wind flow tends to sweep inland air-pollutants toward the Atlantic coast.

References

RI. Cerveny, Randall S., and Balling, Robert C., Jr.; "Weekly Cycles of Air Pollutants, Precipitation and Tropical Cyclones in the Coastal NW Atlantic Región," Nature, 394:561, 1998. (XI)
R2. Cohén, Philip; "Rain, Rain, Go Away...," New Scientist, p. 22, August 8, 1998. (XI)

GWP17 Future Rainfall Correlated with Soil Temperature

Description. The prediction of future rainfall from current deep soil temperatures.

Data Evaluation. A Chinese claim published in an American popular Science magazine. No scientific studies found as yet. Rating: 3.

Anomaly Evaluation. No cause-and-effect link seems to tie future rainfall to present deep-soil temperatures. Rating: 2.

Possible Explanation. Precipitation and deep-soil temperatures may be causally connected but out-of-phase.

Entry

XI. General observations, Accordihg to Chinese scientists, if you dig a hole about 40 inches deep and take the soil temperature at that depth, you can pre- dict future wet and dry periods months ahead of time. To illustrate, warm spring soils are usually followed by rainy sum- mers; coid soils precede dry summers most of the time.

At first, American scientists doubted this Chinese discovery, but their re- search soon proved that the correlation is even stronger in the United States. The best explanation so far is that soil temperatures affect atmospheric convec- tion and modify weather patterns locally. **(RI)**

Reference

RI. Anonymous; "Digging for a Fore- cast," Science Digest, 91:30, Sep- tember 1983. (XI)

GWR TEMPERATURE ANOMALIES

Key to Phenomena

GWRO tntroduction GWR1 Temperature Flashes

GWRO Introduction

Meteorological records often quote high and low temperature extremes but say little about rapid rates of temperature change, which some term "temperature flashes. " To the ano- malist these temperature flashes are much more interesting than mere highs and lows, for they signify violent weather. Although the familiar Chinook winds and thunderstorm activity seem to accompany most temperature flashes, there are some that have no ready explanation.

GWR1 Temperature Flashes

Description. Large, rapid temperature fluctuations, often amounting to tens of degrees in a few minutes. Temperature flashes are often associated with Chinook-type winds in the United States and with their analogs elsewhere. Other temperature flashes sometimes accompany thunderstorms.

Data Evaluation. Several excellent instrumented observations. Rating: 1.

Anomaly Evaluation. The hot, dry Chinook winds are fairly well understood, but the temperature flashes associated with nighttime thunderstorms remain to be elucidated. Other temperature flashes, viz. X2, have no known causatative agent. Rating: 3.

Possible Explanations. Passing over the well-known Chinook winds, one can surmise that thunderstorms are the producís of instability and must therefore consist of regions with strong temperature variations; in other words, the temperature flashes are the consequence of unmixed volumes of hot daytime air. Eléctrica! heating of air by thunderstorm activity is also a possibility, but no evidence has been discovered for this.

Similar and Related Phenomena. Hot air blasts subsequent to lightning strokes. (GLL12)

Examples of Temperature Flashes

XI. September 20, 1911. Kimberley, South Africa. "It may interest you to know that at 9 p. m., on the 20th September, a thunder cloud approached from the west, bringing with it a squall of wind that caused the temperature to rise in a few minutes to 110°F. By 9.45 p. m. it had fallen again to 67°, which I expect was about the temperature before the squall. I do not think my ther- mometer responded quick enough to regi- ster the highest point, but it is safe to say it rose 40° in five minutes. " (R3)

X2. November 4, 1911. Teneriffe, Canary Islands, Spain. A curious heat wave. "At 12:45 A. M. the thermometer at the municipal meteorological observatory registered 63 deg. F. ; it then suddenly rose within two minutes to 79 deg. F., and after re- maining at the latter temperature for a few minutes fell back suddenly to 63 deg. F. During this time the barograph showed mar- ked oscillations of pressure. No satisfactory explanation of this occurrence has been of- fered." (R2)

X3. January 13, 1913. Rapid City, South Dakota. During the onset of a Chinook wind. The 8 A. M. temperature was-17° F; at 10 P. M., it was 47° F; an increase of 64° in 14 hours. (R4)

X4. June 30, 1921. Killarney, Manitoba, Cañada. During a thunderstorm, at mid- night, the temperature rose to 93° F. (R5)

X5. January 22, 1943. Rapid City, South Dakota. Chinook wind. Beginning at 7:32 A. M. the temperature rose 49° in two minutes-----from -4° to 45° F. Frost appeared almost instantaneously on car windshields. (R4)

X6. June 20-21, 1960. Gretna, Manitoba, Cañada. Thunderstorms along an advancing squall line. "After midnight had passed there occurred two sudden and most pro- nounced temperature rises at Gretna. The situation was described thus by the observer on duty:'We had two blasts of hot air from the south of approximately 15 minutes dura- tion each; the first from 0025 to 0040 and the second from 0200 to 0215. The first reached a high of 96° and the second 97°. The wind changed direction several times before and after these periods and at times was calm.' There is no thermograph at Gretna station henee a pictorial record of the temperature variations is not available. The first temperature flash was a rise of 16 degrees the temperature equalling the previous afternoon's máximum. The extent to which the temperature dropped be- tween flashes is not known. The second flash exceeded the previous afternoon's máximum by one degree. The temperature then dropped sharply although again the amount of the sudden drop is unknown. " (R5)

X7. No dates given. Georgia and Kansas. "Several currents of intensely hot air have been experienced which appear to be similar to those which are common in Egypt, Persia, and some portions of India. A hot wind ex- tending about 100 yards in width, lately passed through middle Georgia, and scorched up the cotton crops on a number of planta- tions. A hot wind also passed through a section of Kansas; it burned up the vegetation in its track and several persons fell victims to its poisonous blast. It lasted for a very short period, during which the thermometer stood at 120° far above blood heat. " (RI)

X8. July 11, 1909. Near Cherokee, Okla- homa. At 3 A.M. a heat burst reached 136°F. A small area of crops in the center of the burst were desiccated instantly. (R6)

X9. June 15, 1960. Northwest of Waco, Texas. Right after midnight, a blast of hot wind pushed the temperature from 70° to 140°F. The wind blast was esti- mated to be 80-100 miles/hour. "Cotton fields were reported to have been car- bonized, leaving only burnt stalks standing." (R6)

References

RI. "Hot Weather and Burning Winds, " Scientiflc American, 3:106, 1860. (X7) R2. "A Strange Heat Wave, " Scientiflc American, 104:54, 1911. (X2)

R3. Parkinson, F. B.; "Great Heat in a Thunder Squall, " Symons's Meteorological Magazine, 46:201, 1911. (XI)

R4. Hamenn, Rol and R.; "The Remarkable Temperature Fluctuations in the Black HiUs Región, January 1943," Monthly Weather Review, 71:29, 1943. (X3, X5) R5. Lowe, A. B.; "Temperature Flashes at Gretna, Manitoba, " Weatherwise, 16: 172, 1963. (X4, X5)

R6. Burt, Christopher C,; Ext eme Weather, New York, 2004, p >. 36, 37. (X7-X8)

GWS WEATHER AND ASTRONOMY

Key to Phenomena

GWSO Introduction
GWS1 The Correlation of Lunar Phase and Terrestrial Weather Phenomena
GWS2 The Correlation of Thunderstorms with Lunar Phase
GWS3 Thunderstorms Correlated with Solar Activity
GWS4 The Effects of Meteors on the Weather
GWS5 Correlations between Solar Activity and Weather
GWS6 The Influence of Lunar Phase on Atmospheric Ozone
GWS7 The Lunar Temperature Effect
GWS8 The Purported Effects of the Planets on the Weather
GWS9 Comets and the Weather
GWS10 The Eclipse Wind

GWSO Introduction

Folklore is emphatic that the moon affects rainfall, and a few sclentistshavelong suspected a solar influence on terrestrial weather. Neither effect is overwhelming, whatever the mech- anisms may be, assuming the phenomena really do exist. In fact, the effects are so small that most scientists have pooh-poohed both solar and lunar weather influences for many years. Nevertheless, an immense literature (merely sampled here) definitely favors some statistical relationship between weather and astronomy.

Recently, with spacecraft and rocket measurements, it has become apparent that solar activity can indeed affect the earth's atmosphere through sun-emitted streams of plasma. It is possible that these atmospheric changes may manifest themselves as weather modifications. This new creditability of sun-weather relationships removes some of them from the category of anomalies and thus outside the purview of this Catalog.

The moon's influence on weather, however, remains controversial. Favorable and unfavorable data abound. Three kinds of effects are recognized, each with a proposed physical mechanism:

(1) Lunar modulation of rainfall through atmospheric tides;
(2) Lunar modulation of rainfall through gravitational or electrostatic modifica- tion of the influx of meteoric dust that serves as precipitation nuclei; and
(3) Lunar influence on thunderstorm and lightning incidence through the moon's interaction with the earth's magnetic tail that, in turn, modifies the the number of charged partióles entering the atmosphere and affecting the planet's electrical balance,

Solar and lunar effects on the weather are so muted that other astronomical bodies would be expected to be completely ineffectual. But to be thorough in the search for anomalies, we must ask whether the planets may not modify the weather, too. This effect may be indirect,

for planetary position has frequently (and controversially) been correlaled with solar activity, which Itself may influence the earth's weather. Meteors and even comets must also come under scrutiny, for it is conceivable that sudden influxes of meteoric dust could trigger storms that would otherwlse have never formed. In short, whatever orthodox Science may say today, we should not cióse our minds to potential extraterrestrial modulation of our weather. Only a century ago, the foremost scientists declared with great certainty that the influence of the sun on terrestrial weather was nil and that all who thought otherwise were fools1

It would also be incorrect to be too generous with respect to those statistical correlations of phenomena that seem to have no obvious cause-and-effect relationships. As ESP propon- ents have found to their dismay, poor statistical techniques may suggest influences that simply do not exist. Similarly, improper statistical methods have long dogged the correla- tion of astronomy and terrestrial weather. So often the data employed are insufficient in quantity and quality. The mere comparison of graphs may be misleading if the data are not handled properly. Before Science accepts astronomical influences on weather, the correlations must have high statistical significance. The existence of a recognized physical mech- anism also makes scientific acceptance easier, although mechanisms and theories should not veto good data.

GWS1 The Correlation of Lunar Phase and Terrestrial Weather

Description. The statistical correlation of lunar phase with various terrestrial weather phenomena, such as precipitation, drought, hurricane occurrences, the amount of sunshine, etc. In particular, the relationship of lunar phase and precipitation has received considerable attention in both folklore and the literature of science down the centuries.

Background. Weather lore has long insisted that rainfall is heavier around the time of the new moon. Science has both ridiculed and embraced this contention, presenting data pro and con. Generally, in the past, scientists have rejected a lunar connections because they could not perceive any physical mechanism whereby the moon could significantly affect the earth's weather. In recent times, though, some analyses of rainfall and the timing of the formation of tropical depressions have strongly supported a connection with lunar phase at least in some parts of the globe. In addition, some possible physical mechanisms have now been identi- fied by which the moon can indeed influence earth's weather. Chief among these are lunar tides in the atmosphere. Even so, the statistical picture is often com- plex and sometimes inconsistent.

In passing, it should be recognized that science-in-general has a natural anti- pathy for theories wherein terrestrial phenomena are affected by the movement of astronomical bodies-------doubtless a prejudice derived from an age-old abhorence of astrology.

Data Evaluation. Numerous, each seemingly sound, moon-weather correlations exist, but they are not all consistent. In addition, lunar correlations are always mixed with the sun's influences on terrestrial weather. Separating the two is sometimes difficult. The moon-linked terrestrial variables are also diverse and possibly arise from different lunar-produced physical effects. We see the com- plexity of the analytical situation in the following list of "dependent variables" that appear in the cited studies (X1-X41):

•Rainfall	#Drought
•Wind conditions	«Amount of sunshine
éHurricane onset'	«Tree-ring width
•Sediment-layer thickness	«Winter severity
•Weather-in-general!	

A11 of these have, at one time or another, been used to demónstrate a lunar connection. Obviously, the scientific picture can be quite confusing. Rating: 2.

Anomaly Evaluation. Taking all the data collectively, there is little doubt that the phase of the moon is involved in some aspects of terrestrial weather. The 18.6-year lunar cycle shows up often and emphatically, but so too do other cycles. There is still much to be learned about the moon's impact on the earth's weather. Rating: 2.

Possible Explanations. The lunar tide in the earth's atmosphere somehow affects the above-mentioned dependent variables. The exact mechanisms involved have not been fully worked out. The moon may gravitationally modulate the flux of incoming meteoric debris and thus the amount and distribution of condensation nuclei.

Similar and Related Phenomena. The alleged lunar dispersal of clouds (GWC11); thunderstorm frequency (GWS2); the alleged correlation of planetary configura- tions and weather phenomena (GWS8); the lunar temperature effect (GWS7); lunar phase correlated with atmospheric ozone (GWS6); correlation of auroras with lunar phase (GLA18 in Remarkable Luminous Phenomena in Nature).

Examples of the Relation of the Moon to the Weather

XI. Stalistical analysis. London and vicinity. The analysis of 100 lunar cycles showed that 47.60 inches of rain fell durlng days 3-7, but only 26.42 durlng days 17-22. These periods inelude the times during which the moon ascends and descends through the plañe of the earth's orbit re- spectively. (RI)

X2. Statistical analysis. English wind data from 1840 to 1847. .. it seems that when the sun and the moon were in and near con- junction, the air wás less frequently calm; the duration of the north wind with its east compounds was less frequent; the South wind with its west compounds was more frequent than when the sun and moon were in and near opposition. From this it would seem that the position of the moon in respect to the sun has exercised an influence on the directionof the wind in these years.... The influence of the moon on the temperature, and therefore density, of our local atmosphere, seems to be exercised chiefly through the médium of the winds. It is a secondary effect of her varied attraction, which continually tends to change the bearings of the different cúrrente in the great body of the atmosphere, andwe are successively involved in all their modi- fications. Not but that there are seasons, such as dry years after wet, or vice versa, in which the predominant solar influence is exerted to a degree which renders these lunar changes of small consequence, and when, in spite of the various aspects of our attendant planet, we are drenched with rain or parched with drought for months together. " (R2) This obviously primitive and simplistic view of the weather and its possible rela- tionship to astronomy is included here as a period piece.

X3. Statistical analyses. Two quotes from a cogent survey of several studies of the possible influence of the moon upon weather. "In examining a question of this kind, pre- conceived opinions are very liable to influence the results obtained, except where ab- solute measurements (such as height of bar- ometer, depth of rain, &c. ,)are employed; therefore, though we have lunar maximsand theories more than 2000 years oíd, we leave them unnoticed, for the present at any rate, and with them all but instrumented records, for an observer predisposed to a belief In the influence of limar phases will consider himself warranted in classing as a change in weather a variation which one holding oppo- site views would consider far too trivial to constitute a 'change.'.....Thomas Forster, in his Atmospheric Phenomena, says, 'It is certain that the place of the moon has much influence on the weather. That changes of weather oftener take place about the full and new of the moon and about the quadra- tures than at other times, isreally a fact founded on long observation, and is quite conformable to what we actually know, re- specting the moon's influence on the tides.'" (R3) The latter statement is by a 'believer' in lunar influence and, In the literature of this period (1868) is llterally overwhelmed by condescending comments by 'unbelievers.[1]

X4. Statistical analysis. "Although It seems certain that the meteorological Lnfluence of the moon's phases is very slight, I am prepared to prove ----------as the result of a long series of investigations-------that the declination influence of our satellite is very great. One extremely important secret of lunar lnfluence on the weather is in the principie of uniform- ity-----uniform movements of the moon cau- sing fine weather, and extremes of temper- ature both in summer and winter; while ir- regularity of lunar movements (a condition far more common than uniformity) appears to cause the unsettled weather that usually prevails in this climate. Another extremely important secret of lunar influence on the weather is the distance of the sun from our meridian, or the meridian of the antipodes at the time the moon crosses the equator; for the nearer the sun is to noon or midnight at the time of this lunar phenomenon, the greater the influence of the moon in raising or depressing our temperature according to the season of the year.....In conclusión, I may observe that until the year 1860 I en- tirely disbelieved in the moon's influence on the weather, and invariably ridiculed the theories of lunar meteorologists; but certain phenomena that occurred in that year induced me to examine the subject with some care, and a seven year's investigation of thisbranch of predictlve meteorology has so far converted me, that I have become a lunarlst in spite of my prejudices, and almost against my will. " (R4) Such reluctant conversions are very common in anomaly research.

X5. Review of statistical studies. The lunar effect on weather is essentially nil. The "influence of the planets" is the solé canse of the weather and its variations.
See GWS8 for more on this theory, which smacks even more of astrology. (R5)

X6. General observation. Lunar radiation and tidal pulí are too small to affect terrestrial weather. (R6)

X7. A review of weather lore involving lunar phases. The author generally ri- dlcules any suggestions that the moon has an effect on terrestrial-weather be- cause no known physical forcé is power- ful enough to have an effect. It is akin to astrology and superstition. One ex- ample of lunar weather lore is the so- called "Saturday moon, " which insists when a new moon falls on a Saturday wet and unsettled weather invariably fol- lows. (R7)

X8. Statistical analysis. Bethlehem, Penn- sylvania. "The observations of rainfall, taken at Bethlehem, Pa., by Mr. F.E. Luc- kenbach, during 1881-1890, are selectedas as the basis of a brief dlscussion, and they are believed to be free from the objections above noted. The amount of rainfall ineach year was obtained for the day of new moon and for each of the three days preceding and following, and also for the other quar- ters. For each year a curve of rainfall throughout a lunar month of 28 days could then be drawn, and these curves werecom- bined in varlous ways to endeavor to ascer- tain the features common to all of them.
The following concluslons were derived: First, the new moon is liable to be followed by an increase in rainfall; second, the full moon is liable to be followed by a decrease in rainfall; third, the wettest period is generally at and preceding the full moon; and, fourth, the dríest period is generally at and preceding the flrst quarter. These conclusions are, in general, most plainly marked in the years of least rainfall. "
This study was followed by one by Hazen, uslng Philadelphia data (not far from Bethlehem), in which it was concluded thatthere is little if any lunar effect on rainfall. (R8)

X9. Statistical analysis. East coast rainfall dada. "While both New York and New Haven show an increase at the time of new moon, yet the figures at Boston show a very re- markable máximum at the day of new moon, and an equally remarkable mínimum on the seventeenth day of the lunation, or twodays after full moon. I do not set forth these figures as an absolute prooí that the moon does influence rainfall in the neighborhood of Boston, but it looks as though there must be somethlng in it." (R9) This study is by the same H. A. Hazen mentíoned in X8, where he concluded no effect existed.

X10. Statistical analysis. Greenwich, Eng- land. Data on rainfall from 1889-1900 show máximum wetness near the timeof the new moon with a mínimum shortly before the last quarter. (RIO, Rll)

Xll. General observation. Scientific men of the present day (1902) see no reason whatsoever for imputing to our satellite even the slightest change in the weather. It is all superstition. (R12)

X12. Statistical analysis. Barometer data from Greenwich (1889-1904) and Ben Nevis (1884-1892) tend to substantiate the notion from folklore that the full moon brings fine weather. Referring to his graphs oí average valúes. "These two curves seem to tcllmuch

the same tale; few days of low barometer about (just aíter) full and new moon, many such days about (just alter) the quarters. Thus, so íar as the summer half in those twenty-one years is concerned, the popular belief would .appear to be vindicated. " (R13)

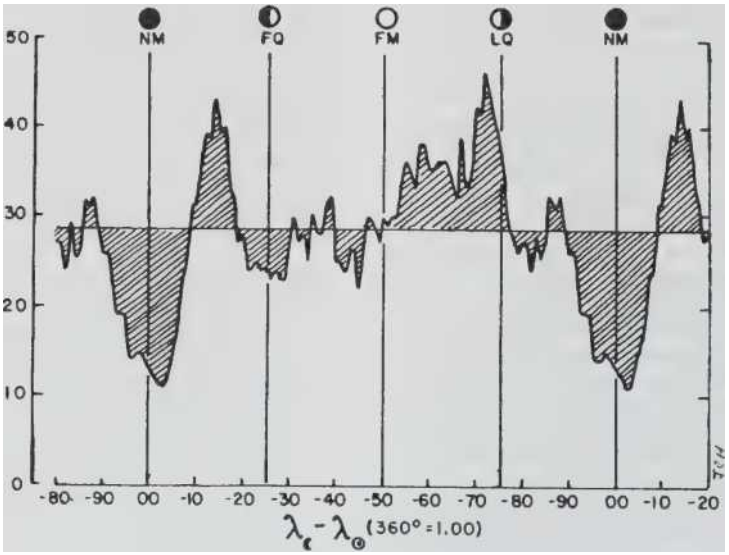
X13. Revlew oí weather folklore. A typical condescendlng discussion oí popular weather lore, which emphasizes the fact that the moon's heat and gravitational forcé cannot possibly affect terrestrial weather. All lunar weather lore isthus merely superstition. (R14)

X14. Statistical analysis. Glasgow Obser- vatory's hourly barometric pressure reading from 1868-1912. A strong di- umal variation was shown to exist at Glasgow in contrast to other sites where the variation is semidiurnal. No satis- factory explanation exists for this anom- aly. (R15)

X15. Statistical analysis. 41 limar cycles from Shangugu, Ruanda. A27-daycycle in precipltation was confirmed. (R16)

X16. Statistical analysis. United States. "Abstract. Precipitation activity overbroad areas appears to be closely associated with the monthly 1 uní solar cycle. Indexes of pre- cipitation in the continental United States over a continuous 50-year period, and 91- year daily histories of individual stations, reveal that heavy rains occur most frequent- ly in the first and third weeks of the synod- ical month. " (R17, R18, R20)

X17. Statistical analysis. New Zealand. "The influence of the moon in producing tides in the upper atmosphere and the ap- pearance of a lunar component in daily tem- perature in certain parts of the world are comparatively well known, but the effects are extremely small and difficult todetect. The possibllity of a large eífect on raintall first carne to our notice in 1960 with the chance reading of a paper by Rodes. Rodes showed what appeared to be a connection be- tween rainfall in the Spanish península and both the decllnation and the position of apogee and perigee of lunar motion. An invest- igation was therefore made of the rainfall data in our possession, and it was apparent that it contained a strong lunar component. However, it was also clear that this was connected with the phase of the moon rather than with the parameters used by Rodes. At this point a decisión was taken not to publish the data immediately, but to reserve it for a later date. The reason for doing so was that our work on singularities in rainfall was still being treated with disbelief in me- teorological circles, and to suggest a lunar effect on rainfall would simply not have met with the right response. We were not sur-



Ten-unit moving totals of the heaviest falls of the month, for fifty New Zealand stations, 1901-1925

prised therefore when we received a com- municatlon from Bradley, Woodbury, and Brier indicating a pronounced lunar effect in U.S. rainfall. The effect is matched by similar effects in the Southern hemisphere.
A curve showing the heaviest falls of the month for 50 stations in New Zealand, plot- ted in the same way as the U. S. data are plotted, is given in Fig. 1. It shows vari- ations of a magnitude comparable with those in the U. S. and closely related in phase. " (R18, R20)

X18. General observation. In response to X16 and X17, widespread precipitation is frequently associated with hurricanes, which are in tura probably influenced by the moon's tidal action during their for- mative period. (R19)

X19. Statistical analysis. Indiana. "About 10 years ago I was working on weekly rainfall totals and their effect on cora yields for 15 counties in central Indiana. From folklore I had learned that precipitation was more likeiy to occur during the week follow- ing a new moon and the week following a full moon than at other times, so I proceeded to test this idea. To my amazement I found some agreement. After applying several statistical treatments to the data I produced a short manuscript as well as an outline sug- gesting some further investigations along this line. I need not relate here the review comments or the outcome of the proposed investigations. In short, the whole matter was dropped. " (R21)

X20. Statistical analysis. After presenting a series of graphs showing ice nucleus con- centrations in the Southern hemisphere, E.K. Bigg observed:
"The result is as surprising as the rainfall discoveries. In every case, there are two distinct maxima in the lunar month, about the first and third quarters of the Moon, and the total range is three or four to one, even with the smoothing used. There appears to be a slight shift with latitude, the peaks occurring later nearer the equator....
It is apparent, therefore, that, in addition to the effect on rainfall, the Moon has a large effect on the freezing nucleus count. It is well known that the effect of the Moon on other meteorological variables like baro- metric pressure, surface temperatura, is extremely small; the implication is strong, therefore, that the effect on the freezing nucleus count does not originate in the lower atmosphere. However, a possible mechanism is that the Moon in some way Controls the in- coming meteor rate and so affects the num- ber of freezing nuclei falling into the lower atmosphere. " (R22, R23)

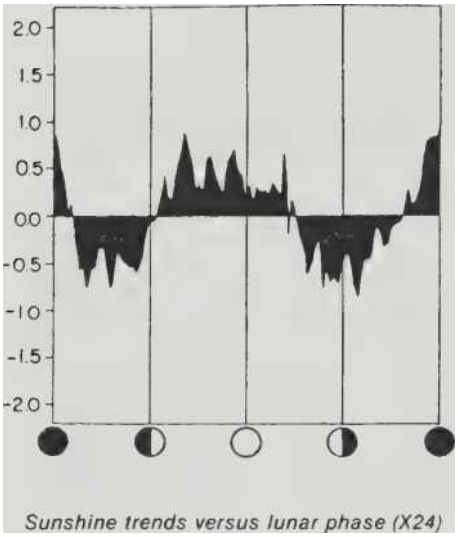
X21. Survey paper. A review of the data presented in R18, R19, and R22, plus a discussion of the theory that the moon and meteoric particles are electrically charged. The moon would thus deflect like-charged meteoric particles away from the earth during part of the lunar cycle, consequently affecting rainfall.
(R23)

X22. Statistical analysis. United States. "A cycle of 14.765 days, one-half of the limar synodic month, can be demonstrated in the precipitation data for the United States for the period 1871-1961. Numerous rigorous statistical tests show that the association is real and an estímate is obtained of the magnitude of the limar effect. Geographical, seasonal and other sources of variation in the effect are suggested by the data. No other periodicity with comparable amplitude was found by the statistical analysis, but there is evidence that the lunar synodic cycle interacts with the nodical cycle. " (R24)

X23. Statistical analysis. Atlantic hurricanes. "An American research worker reporte an apparent connection between the phases of the Moon and the génesis of hurricanes. Donald A. Bradley, of the College of Engineering, New York University, took the records of 269 Atlantic hurricanes be- tween 1899 and 1958. He noted the positions of the Moon on dates when they 'matured', in other words, when they first developed winds of forcé 12 on the meteorologist's Beaufort scale. His figures show that 90 of the hurricanes matured within 46 hours of either New Moon or Full Moon. That is 20 or more than one would expect if there was no connection between the weather and the lunar cycle and is, in statisticians' terms, highly signíficant." (R25)

X24. Statistical analysis. United States. "Abstract. An analysis of daily observations of sunshine taken in the central and north- eastern United States during the spring and summer indicates the presence *oí* a lunar synodical period. Less than average sunshine is observed during the first and third weeks of the lunar month and more than average sunshine is observed during the second and fourth weeks. Although this lunar period is signíficant by most statistical tests, the possibility that its appearance is due to a combination of the smoothing pro- cedure and the temporal and spatial corre- lation among the observations cannot be com- pletely ignored. " ÍR26) See GWC11 for data

on the possible dispersal of clouds by the moon.

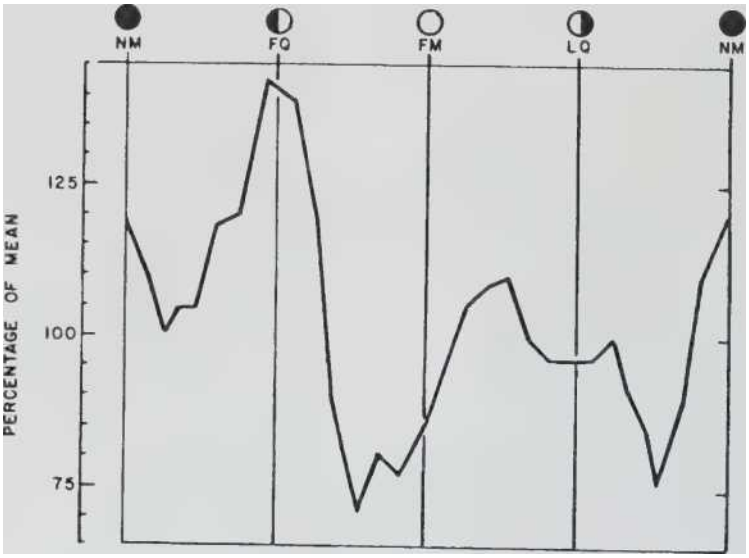


Sunshine trends versus lunar phase (X24)

X25. Statistical analysis. Sydney, Australia. 'Summary. Daily rainfalls of an inch or more for 100 years at one station have been classified according to the phase of the moon with which they occurred. An apparent significant correlation between two 50-year smoothed sub-series is found to have been induced by the filtering process of taking sums. When the effects of the ensuing serial dependence are eliminated, the results are not indicative of a significant overall relationship between the series of rainfall and moon phase." (R27)This síems to con- tradict other data from the Southern hemi- sphere; viz. , X17.

X26. Statistical analysis. South Africa. Ab- stract. "Rain and hail data from five mete- orological stations on the plateau of South Africa have been examined for a dependence on lunar phase. Different distributions with respect to lunar phase were found for summer and winter data. Statistical analyses of the winter descriptions, which appeared to be more significant than those for the summer, suggested that winter rain is modulated by the moon in such a manner that there is one component with the same period as the luni- solar cycle which depends on station latitude and another having three peaks which is latitude independent. This three-peak component seems to opérate throughout the year. " (R28)

X27. Statistical analysis. Indian Ocean. "The data for this investigation were taken from a publication issued by the Indian Meteorologi-



Frequency of atmospheric depressions, 1877-1960, in the Bay of Bengal and Arabian Sea (X27)

cal Department which catalogues depressions formed in the Indian Seas, and gives the date on which the depression stage was reached and its corresponding posltion. The phaseof the Moon for each day is given in terms of synodic decimals (hundredths of a synodic month) in the ephemeris by Carpenter. The synodic decimal corresponding to each date was taken from that source and the frequency of formation of depressions corresponding to each synodic decimal was found. Successive ten-unit moving totals of the frequencies were then made, and of the hundred such to- tals thirty were chosen to correspond to the thirty days of the lunar month. For purposes of comparison the frequencies were expres- sed as percentages of the mean. Fig. 1 shows the curve, prepared in this manner, of depressions which formed in the latitude band 19°N - 22°N in the Bay of Bengal and Arabían Sea during the period 1877-1960.... There is a strong indication that the heavy falls (of rain) were associated with the depressions. The tidal influence on the formation of depressions is also indicated, as in both curves the 14. 765 day wave ac- counts for 48.1 of the total variance andis the largest component. " (R29)

X28. Statistical analysis. Worldwide study. "Abstract. To examine the hypothesis of a worldwide relation between some lunar per- iods and tropical disturbances, we collected first-formation dates for 1,013 hurricanes and typhoons and 2,418 tropical storms in both hemispheres. Using the superposed epoch method, we found a lunar synodic cycle (29. 53 days) in North Atlantic hurri- cane and northwest Pacific typhoon formation dales. About 20 percent more hurricanes and typhoons formed near new and full moon than near the quarters during a 78-yr period, showing a stronger peak at new moon than at full moon. Statistlcally, the existence of an effect dependent on the lunar synodic cycle is supported by a sig- nificance level of 7 percent on unsmoothed data from an analysis of variance for cate- gorical data. During the same 78 yr, North Atlantic tropical storms that did not later become hurricanes tended to form near the limar quarters. Several other categories of tropical storms were not clearly related to the synodlcal month. Severe tropical storms in two portions of the Indian Ocean over 75 yr formed more often several days after syzygy and quadrature, bul this and other severe tropical storm resulta lack definition, probably due to poor data. Theo- retical calculations of the lunar-solar gra- vitational tide showed that the anomalistlc lunar cycle affects only the amplitude and not the timing of extrema. No marked anomalistlc or latitude componente in hur- ricane formation were found. " (R30)

X29. Statistical analysis. New South Wales, Australia. "An examination of the weather of one hundred years of New South Wales has shown that certain features recur every nineteen years; we have seen that the droughts of history------the great and conspic- uous droughts I mean-----all drop into this same cycle; both those that happened before the birth of Christ, and those that have oc- curred in our era; for instance, Elija's drought happened in B. C. 908, that is,2736 before our great drought in 1828, and the interval is 19 x 144. Great hurricanes, the great frosts of history, all the red rains, and all the droughts that history records, with a very few exceptions, likewise are in- cluded in this cycle, and the level of great lakes in Palestine, South America, and New South Wales are subject to the same myster- ious influence that Controls our weather.

As my investigation proceeded, theweight of evidence gradually converged upon the moon as the exciting cause. I have neverhad any sympathy with the theory of lunar influence upon weather, and received, rather against my will, the evidence that presented itself; stlll the logic of facts left no alterna- tive but to accept the moon as prime motor. There has not been time to complete this investigation, and when finished it must form another paper. Meantime I may say that, so far, the comparison of the moon's position in relation to the sun and earth and droughts shows that when the eclipses congrégate about the equinoxes, that is, in March and September, they do so in the years which give us great droughts. Further, that when the eclipses accumulate in February and March, that is, at the vernal equinox and the month before it, and September, the autumnal equinox, and the month before it, August, we have the more intense and rela- tively shorter droughts of the second series, with heat, gales, and hurricanes; on the other hand, when they accumulate about March and April, that is, the month of equinox, and the one following, and about September, the month of equinox, and October following it, we have droughts of the first series that are less severe, but much longer than the droughts of the second series. I have spoken chiefly of droughts; though, so far as our own history Is concerned, itwould have served the purpose just as well if 1 had taken up the periodicity of wet years, but outside Australia it would have been very

difficult to get the necessary data, for history has much more to say about the horrors of drought than the abundance of wet seasons. " (R31)

X30. General observations. The "20-year" droughts of the American Midwest may ac- tually be controlled by the lunar 18-year cycle, for the data fit the 18-19 year cycle just as well as they do the 21-22 year double sunspot cycle. (R32) "It now looks verymuch as if western US droughts over the past four centuries have been modulated at periods of
22 and 18.6 years-----corresponding to domi- nant solar and lunar cycles. This explana- tion of why the solar and drought cycles do not always march in step greatly strengthens the case for some solar variability influ- ences on western US droughts. " (R33)

X31. Summary of pertinent studies from 1983. (1) Analyses of tree-ring data from the western United States by R.G. Currie (X33, X35), and (2) Beijing pre- cipitation records by S. Hameed et al (X32). Both studies suggest that rain- fall/drought exhibit a strong 18.6-year lunar signal. (R34) See X32, X33, X35 for details.

[Currie's] "explanation for the phe- nomenon links the extreme movement of the Moon north or south of the equator (which follows the 18.6-year cycle) with shifts in the prevailing weather moving from west to east around the Rockies, either to the north or south." (R34)

The modern view is that lunar tides in the earth's atmosphere affect the distribution of precipitation.

X32. Hameed's historical study of Beijing rainfall records. Using the dryness/ wetness Índex for Beijing 1470-1974,
S. Hameed et al found a "significant signal at 18.7 years." This is a com- ponent of the tide-generating forcé.
The team also found a significant 80- year signal. However, the expected 11-year and 22-year solar cycles were weak or nonexistent. (R35)

X33. Analysis of tree-ring data from western North America. "Analysis of 102 recent tree-ring chronologies confirms earlier evidenee for 18.6-year drought/ flood induetion and led to discovery of 11-year solar cycle induced drought/ flood for western North America." (R36)

X34. OverView of solar/lunar effects on rainfall/drought. R.A. Kerr introduced this Science article by emphasizing the historical inconclusiveness of such in- vestigations of astronomical effects on terrestrial weather and climate. Kerr wrote:

"Cyclicity is the bugaboo of climate studies. Many cycles are reported, few are confirmed. The dubious reputation of most cyclicity studies makes the recent discovery of the moon's periodic influ- ences on weather all the more startling. Although it is a subtle effect, the lunar cycle that influences droughts in the American Great Plains, in combination with a previously reported solar influ- ence, may on rare occasions wreak such widespread havoc as the Dust Bowl of the 1930's."

Kerr related how early studies of tree-ring data seemed to indícate a 22- year drought cycle in the American Great Plains. This 22-year signal was small but nevertheless had gained wide- spread support circa 1980. Then, R. Currie (R36 and R38), to everyone's sur- prise, claimed an 18.6-year lunar signal in the rainfall/drought record for western North America, but at the same time Currie denied the presence of a 22- year solar signal. However, Currie did see an 11- year sunspot signal in his tree-ring data. Thus, in 1984, the effects of the sun and moon on terrestrial rainfall were unclear. However, the reality of an 18.6-year lunar cycle in precipitation was finally generally aeknowiedged.
(R37)

X35. More evidenee for a lunar effect.
An additional study by Currie.

"Analysis of 38 tree-ring chronologies yields evidenee for enhanced drought conditions every 18.6 years in the North American interior for the past millennium. (R38)

X36. Tree-ring data from the Corn Belt.
A 1985 paper by D.M. Meko et al in Science further muddied the waters when they shifted tree-ring studies farther east into the Corn Belt (Iowa, Illinois, etc.) . They wrote:

"Recently collected tree-ring data from the U.S. Corn Belt for the years 1680 to 1980 were examined for evidenee of either these cycles [18.6-and 22-year] on a regional scale. Spectral analysis indicated no periodicity in the eastern part of the Corn Belt, but a significant

18.33-year period in the western part. The period length changed from 17.60 to 20.95 years between the first 150 years and the last 151." (R39)

Why the puzzling shift in period length? Why different resulte for the eastern and western sections of the Corn Belt?

X37. Ineonclusivity reigned in 1985. Science News remarked that Meko's 18.33- year periodicity (X36) could not be ascribed to either the moon or sun.

Because severe droughts tended to occur 2 years after altérnate altérnate lows in the sunspot cycle, Meko opined that the solar influence probably out- weighed that of the moon. (R40)

If droughts skipped every other sunspot low, a 22-year cycle is implied.

X38. A lunar effect on Nile floods. R. Currie extended his studies of the moon's influence on rainfall to Africa. He ero- ployed the long series of records of summer and winter flooding in the Nile región that began in 622 A.D. and ended in 1490. The 18.6-year lunar cycle showed up strongly. The evidence for a 10-to-ll year solar-activity cycle was present, too, but weak. (R41)

X39. Astronomical influences on ancient sediment layers ("varves"). The geologi- cal evidence is seen in the sediment layers of the 60-million-year-old Elatina formation in South Australia. The thick-ness of each varve is taken as a measure of annual rainfall. Solar and lunar cycles of 10.8- and 20.3 years were easily discerned. The timing of the lunar signal was different from that of today because the moon was closer to the earth 60 mil-lion years ago.

Interestingly, the fact that the lunar cycle was almost double that of the sun created a strong "beat" effect. Quite obvious in the data, the beat period is 28.4 sunspot cycles long. (R42)

X40. Unexpected rainfall cycles. Using rainfall records from 234 British weather stations, covering the period 1881-1986, B.R. May and T.J. Hitch picked out two previousiy unrecognized cycles from these records.

"The meteorologists found four signifi- cant patterns of variation [of rainfall] which follow closely sine waves of period 7, 11, 20, and 50 years. The 20-year cycle, sny Mav and Hitch, may match a well-known variation in the strength of tides raised in the atmosphere (and the oceans) by the Moon, a rhythm which repeats every 18.7 years.

"The 11-year cycle is even more clearly tied to the cycle of activity of the Sun, with the heaviest burst occur- ring when the Sun's activity is near its peak. As yet, Hitch and May have no explanation for the cycles 7 and 50 years long." (R43)

Note that the length of the record used is only 105 years long!

X41. Timing of lunar phase related to severe winters. J.H. Graham speculated as follows in a 1991 issue of Weather.

"In 1985 I put iorward the idea that that the timing of the lunar synodical cycle [29.531 days] in preceding months might influence the development of winter circulation patterns affecting England and the rest of western Europe. It ap- peared that severe winters only followed when spring tides fell on specific calendar days. There have since been two winters within the first quintile of severity in central England, 1984/85 and 1985/86, the former being exceptionally severe in other parts of western Europe. Both winters followed the lunar model pre- viously indicated." (R44)

Since winter serverity usually in- cludes snowfall as well and low tempera- tures, we catalog this curious and hard- to-explain astronomical effect here.

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GWS2 The Correlation of Thunderstorms with Lunar

Description. The supposed tendency of thunderstorms to be more frequent around the time of the new moon. This phenomenon is not clear-cut and is, of course, embedded in the lunar rainfall effect (GWS1).

Data Evaluation. As with GWS1, the statistical analyses-of available data are in conflict, even though based upon many years of observations. Different geographical areas seem to encounter different moon-thunderstorm relationships, suggesting a complex relationship or perhaps none at all. Rating: 3.

Anomaly Evaluation. The magnitude of the anomaly here depends upon whether current sci- entific theories of thunderstorm development can countenance a lunar effect. Since thunder- storm frequency seems to be related to solar activíty (GWS3) and the state of the terrestrial- atmospheric electrical Circuit, any lunar disturbance of these relationships might carry through and affect thunderstorm frequency. The moon does, in fact, pass through theearth's magnetic tail and neutral sheet, providing a mechanism that could explain any positive correlation between lunar phase and thunderstorm frequency. Rating: 3.

Possible Explanations. The moon's passage through the terrestrial magnetosphere may modulate the number of charged particles reaching the earth from the sun, thus disturbing the terrestrial-atmospheric electrical current and thunderstorm formation.

Similar and Related Phenomena. The correlation of thunderstorm frequency with solar ac- tivity (GWS3); the relationship between thunderstorms and cosmic rays (GLL16).

Examples of Thunderstorms Correlated with Lunar Phase

XI. Statistical analysis. Greenwich, England. Thunderstorm frequency is máximumnear the new moon and minimum between the ful! moon and the last quarter. (Rl)

X2. Statistical analysis. Providence, Rhode Island. Comparing American data with that of XI, thunderstorm frequency is máximum between new moon and the first quarter, minimum from the first quarter to full moon. The Providence data were so different from those from Greenwich that the author ventured that the effect must be quite different at Greenwich or that the moon really has nothing to do with thunderstorm frequency. (R2)

X3. Statistical analysis. Bridport, England. More thunderstorms were recorded near the full moon than the new moon, in con- tradiction of XI (Greenwich) observations. (R3)

X4. Statistical analysis. Germany. "Tomost of us who have been brought up to consider that it is rank heresy to suggest that the Moon has any influence on the weather, itis a little startllng to look up the amount and quality of the data that have been collected upon this subject, especially in Germany.
The point which seems to have been partlc- ularly investigated is the relation of the phases of the Moon to thunderstorms. " A large table of Germán data is omitted here. "The number of observations here collected seems to be large enough to enable us to draw definite conclusions, without fear that further records will revise or neutralize them. From these observations we conclude that there really is a greater number of thunderstorms during the first half of the lunar month than during the last half, also that the liability to storms is grealest between new moon and the first quarter, and least between full moon and last quarter. Also we may add that while theoretically very interesting, the difference is not large enough to be of any practical consequence. Thus it would seem that besides the tides and certain magnetic disturbances, there is a third influence that we must in future at- tribute to the Moon." (R4, R5) Note that W. H. Pickering, the author of this article, held many unconventional views with regard to the moon.

X5. Statistical analysis. Northern Italy. A review of the studies of Schiaparelli, using 1827-1864 data, arrives at a conclusión exactly the reverse of Pickering (X4). (R6)

X6. Statistical analysis. United States, "Ab- stract. Using the superposed-epoch method,

we statistically analyzed thunderstorm frequencies for 108 stations in eastern and central United States In relation to ltinar posi- tions for the years 1930-1933 and 1942-1965. The resulta are as follows. With full moon as key day, a peak in thunderstorm frequency occurs for 1953-1963 two days after full moon, the mean being 2. 7<r above average level. This mean frequency is 4. 8<r above the mean when computed only for the full moons as key days that have a declination of 17° north or more. We suggest that these Increasesnear full moon may be related to the earth's mag- netic tail and the neutral sheet." (R7)

X7. General observation. "Many facts rela- tive to the cause of storms are still unknown; no reason can be given for the fact that on the shores of the North Sea, of the Gulf of Bengal, and many other regions bordering the ocean, thunderstorms almost always commence at the hour of high tide. " (R8)

This is the only allusion we have found to this remarkable phenomenon.

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GWS3 Thunderstorms Correlated with Solar Activity

Description. The increase of thunderstorm frequency and/or lightning incidence during short-term solar fiares and long-term, more general increases of solar activity. This relationship can be seen in the historical analysis of thunderstorm and lightning incidence and also in direct measurements of the electrical properties of the atmosphere, such as electrical conductivity.

Background. It is well-established that aurora frequency increases with solar activity. A few investigators have maintained that a reciprocal relation holds between auroras and thunderstorms, both being in effect competing mechanisms for carrying electrical currents in the upper atmosphere. In other words, when auroras wax, thunderstorms wane.

Data Evaluation. Modern measurements of atmospheric electrical properties via balloon and rocket are quite convincing. However, the statistical analyses of thunderstorm/light- ning incidence versus solar activity are sometimes conflicting and may inelude a confusing latitude effect. Rating: 3.

Anomaly Evaluation. A reasonable physical mechanism involving solar cosmic rays describes how increased solar activity can increase the initiation of lightning and, therefore, thunderstorm frequency. The postulated essential role of cosmic rays is recent and is not yet universally accepted. Rating: 3.

Possible Explanations. Ionizing radiation from the sun and cosmos change the electrical properties of the atmosphere and thereby foster the initiation of lightning discharges.

Similar and Related Phenomena. Solar activity affecting terrestrial weather (GWS5); lunar phase related to thunderstorms (GWS2); cosmic rays correlated with the incidence of lightning (GLL16); the apparent reciprocal relationship between auroras and hghtning (GLA9). The last two references are to be found in the catalog Remarkable Luminous Phenomena in Nature.

Examples of Thunderstorms Correlated with Solar Activity

XI. Statistical analysis. Kremsmunster, Germany. Thunderstorm observations made between 1764 and 1869. "In years when the temperature is high and the sun's surface rel- atively free from spots, thunderstorms are abundant. Since, moreover, the maximaof the sun-spots coincide with the greatest in- tensity of auroral displays, it follows that both groups of phenomena, thunderstorms and auroras, to a certain extent supplement each other so that years of frequent storms correspond to those auroras, and vice versa. He (W. von Bezold) observes that such a con- nection between sun-spots and storms does not by any means sanction the suppositlon of a direct electrical interactioft between the earth and sim, but may be simply a conse- quence of a degree of insolation dependent upon the sun-spots." (Rl, R2) Today, space experiments do find a direct electrical con- nection between earth and sun—-the solar wind.

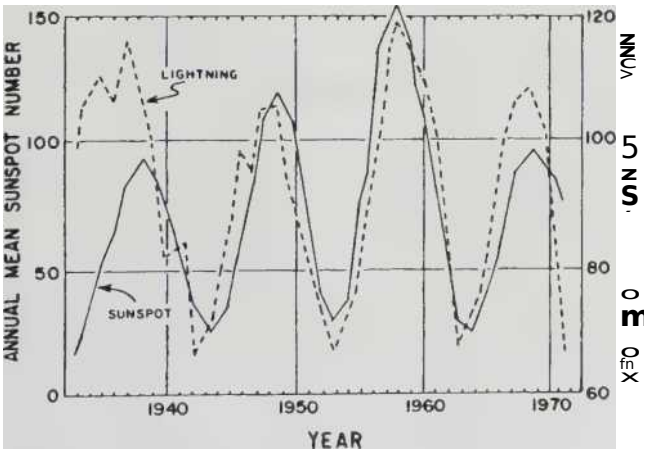
X2. General observations. Conclusions from a long study. "As a result of the extended series of observations described, it has been found in general that whenever groups of faculae, with or wíthout dark spots, are appearing by rotation or are bursting forth upon the eastward side of the sun there is an immediate increase in thunderstorms in the lower latitudes, and probably of auroras in the higher latitudes. If, however, the aurora becomes visible nearer the equa- tor at such times, there is an immediate, though perhaps temporary, decrease inthun- der-storms, as though the aurora had taken their place. In short, the aurora and thun- der-storms appear to have a common origin, and in certain localities, at least, a recip- rocal relation to each other. Instances have been noted also in which an aurora in the United States has been coincident with unus- ual electrical storms in Europe, and vice versa." (R3, R16)

X3. Statistical analysis. Geneva, Switzer- land, and Berlín, Germany. Data from 1850-1891. The máximum in thunderstorm frequency occurs when sunspots are fewest. (R4)

X4. Statistical analysis. Siberia, Russia. Data from 1888-1924. Thunderstorm frequency peaks when sunspot number peaks. (R5) This is, of course, just the opposite of X3. Does it indícate that the correlation is dependent upon geogra- phy ?

X5. Statistical analysis. England. Lightning incidence records from 1930-1973. "There is a clear-cut cyclic varíation in the thunderstorm incidence which varíes with an 11- year cycle, in phase with the solar activity, and with an amplitude of *30 per cent ofthe mean----a real enough effect indeed!" (R6, R7)

X6. General observations. Correlative evi- dence accumulatlng since 1926 suggeststhat there must be some physical coupling mech- anism between solar activity and thunderstorm occurrence in middle to high latitudes. Such a link can be provided by alteratlon of



Lightning incidence compared with the sunspot number (X5)

atmospheric electric parameters through the combined influence of high-energy solar protons and decreased cosmic ray intensitles, both of which are associated with active solar events. The protons produce excess ioniza- tion near and above 20 km, while the For- bush decrease causes a lowered conductivity and enhanced fair-weather atmospheric electric field below that altitude. Consequent effects ultimately lead to a charge distribu- tion similar to that found in thunderclouds, and then other cloud physics processes take over to generate the intense electric fields required for lightning discharge. " (R8, R9)

X7. General observations. Thunderstorm frequency in so me regions is positively correlated with sunspot number. The triggering mechan i sms proposed are essentlally those of X6. (RIO)

X8. General observations. A detailed sce- nario in which cosmic rays initiate and control the development of lightning. (Rll)

X9, August 1972. Worldwide phenomenon. "A direct observation of solar fiare modifi- cation of thunderstorm driven electric fields is presented. During the August 1972 solar fiares the vertical atmospheric electric field in the stratosphere decreased by ai least an order of magnitude. The electric field decrease can be explained by a model in which the electrical conductivity is enhanced by ionization due to the solar protons. A global Índex of VLF whistlers shows a large increase at the time of the solar protón máximum, thereby indicating a possible worldwide high latitude enhancement in thunderstorm activity. Modele of thunderstorm triggering mechanisms which are supported by these data will be discussed. " (R12, R13)

X10. November 1979. Antárctica. "Last November, a sequence of balloons waslaunched at the same time as a major solar fiare. At first, no changes in the weakair- to-ground cúrrente were recorded but sub- sequent balloons showed a major rise over a period of two days, eventuaíly saturating the electrosondes between 25 and 30 km height. This implies an increase in current of more than 70 per cent. The surge was followed by a gradual return to a normal weak current-----clearly bursts of energetic partióles from the fiare enhanced the weak current. This could raise the frequency of lightning flashes in thunderstorms and increase their rain-producing activity. The Sun could be an external driving forcé on the severity of the 1500 or so thunderstorms which are active on Earth at any one time. The global **Circuit** theory **must** now be modi- fied to accommodate solar as well as thunderstorm **effects.**" (R14)

Xll. General observation. Electrification of the terrestrial atmosphere is strong- ly affected by cosmic rays. Therealso seems to be a thimdercloud electrical mechanism that Is sensitive to atmospheric electrification, so that thunderstorms (and lightning) are influenced by cosmic rays. (R15) Solar activity produces some of the cosmic ravs incident upon the earth.

X12. Weather-station survey. For the years 1954-1976 in the eastern two- thirds of the U.S., the number of sta- tions reporting a thunderstorm is correlated with solar activity in several ways. During the five days when a solar active región having a sufficiently high level of activity is near central meridian (CM) on the solar disk, the number of stations reporting a thunderstorm is abnormally large. The mínimum number in this report occurs when the plage is 10-14 days past CM. The threshold of activity required to produce this effect is higher during solar máximum than during mínimum. (R17)

X13. Measurements of electrical currents in the atmosphere. Data collected from electrosondes (balloons measuring atmospheric electrical currents) over the Antarctic ice caps infer that solar fiares stimulate large surges in the flow of electrical charge from the upper atmosphere to the earth's surface. Because this unidirectional flow of fair-weather electricity must ultimately be balanced by thunderstorms somewhere on the planet, it follows that the frequency and severity of terrestrial thunderstorms are dictated, at least on the average, by solar activity. Formerly, global Circuit theory had it that the thunderstorms themselves were the driving forcé behind the fair-weather current flow. Now it seems that the sun calis the tune and that thunderstorms do not arise at ran- dom. (R18)

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GWS4 The Effects of Meteors on the Weather

Description. The correlation of weather phenomena with meteor showers, especially the apparent peaking of rainfall approximately 30 days after prominent meteor showers.

Data Evaluation. Several analyses of rainfall data indícate strong positive correlations with well-known meteor showers, but the correlation of rainfall with visual meteor rates is weak. Rating: 2.

Anomaly Evaluation. Although meteoric particles are acceptable nucleating agents and could enhance rainfall, the rainfall peaks should theoretically be spread out in time, but instead they are sharp. This puzzling detail is probably well within the explanatory capabilities of current theories. Rating: 3.

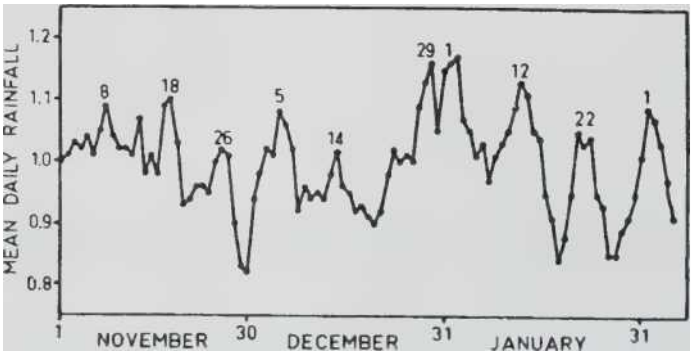
Possible Explanatioris. Meteoric particles serve as precipitation nuclei.

Similar and Related Phenomena. The correlation of lunar phase with terrestrial weather (GWS1), which may depend upon lunar modulation of meteor flux.

Examples of the Effects of Meteors on the Weather

XI. General observations. After a discus- sion of Erman's theory that the so-called "coid days" occurring in February, April, and May are due to the partial screens of the earth by meteor streams. "I have been in the habit of regarding Erman's theory as probably erroneous altogether, thoughnoting that it would have to be accepted if any evi- dence were obtained showing the whole Earth, and not Europe only, to undergo these periodical refrigerations. Mr. Rus- sell, Government Observer at Sydney, has recently published evidence which seems to go a great way towards proving that this really is the case. In Australia and in America, it would seem, the average tem- perature of the coid days is lower than it should be if the seasonal rise from January to July were steadily maintained. He also quotes evidence obtained in Galileo's time, which shows that the same peculiarity was recognized in Europe more than two cen- turies and a half ago. That sometimes the fall of temperature must have been very marked is shown by the existence of popular proverbial expressions, doggerel ver- ses, and so forth, in reference to these coid spells." (RI) Little credence is given, to this theory today.

X2. Statistical analysis. "Examination of rainfall figures for a large number of sta- tions shows that there is a tendency for more rain to fall on certain calendar dates than on others. There is a cióse corres- pondence between the dates of the rainfall maxima in both the northern and Southern hemispheres, and this is difficult to ex- plain on a climatológica! basis. Theeffect might, however, be due to an extraterres- trial influence. The rainfall peaks occur approximately 30 days after prominent meteor showers, and it is suggested that they are due to the nucleating effect of meteoric dust falling into cloud Systems in the lower atmosphere, the time difference being accounted for by the rate of fall of the materia] through the atmosphere. The hypothesis is tested for a particular meteor stream, the Bielids, which is known tohave a 6. 5-year period. The rainfall 30 days after the meteor shower is found to have a similar period. Furthermore, the phase of the rainfall periodicity is almost identical with that of the meteor shower. The data examined are confined to the month of January, and it



World rainfall as aftecleó by meteor showers (the numbers above the peaks indícate specific meteor

is proposed to extend the investigaron to other months in future papers. " (R2)

X3. General review of the meteor hypothe- sis put forward in X2. Studies subsequent to X2 have established fairly firmly the reality of world-wide, annually recurring singularities in rainfall, which seem to require an extraterrestrial mechanism. The striking feature of the meteor hypo- thesis Is the 30-day delay between the meteor shower and the rainfall peak. The peak is explained in terms of the time of fall of the meteoric particles; but thedif- ferent rates of fall of the different sized particles should smear out the rainfall peak. Gn the contrary, the rainfall peaks remain Sharp. (R3)

X4. Statistical analysis. "Abstract. Recently published data on the average hourly rates of visual meteors for each night of the year have been compared with the average daily precipitation of a number of stations for a 50-year period. No significant relation was found between meteor showers and precipitation although there was a very slight sug- gestion of a máximum in precipitation around 30 days after peak meteor activity.: (R4)

References.

RI. Proctor, Richard A.; "Meteors and Meteorology, " Royal Astronomical Soci- ety, Monthly Notices, 43:110, 1883. (XI) R2. Bowen, E. G.; "The Relation between Rainfall and Meteor Showers," Journal of Meteorology, 13:142, 1956. (X2)

R3. Fletcher, N. H.; "Freezing Nuclei, Mete ors, and Rainfall, " Science. 134:361, 1961. (X3)

R4. Brier, Glenn W.; "Visual Meteoric Activity and Rainfall Singularities," Journal of the Atmospheric Sciences, 19:56, 1962. (X4)

GWS5 Correlations between Solar Activity and Weather

Description. The correlation in time of various weather-related phenomena (rainfall, temperature, droughts, tree-ring thickness, etc.) with solar activity as usually measured by sunspot number. In addition to the possible short-term direct influences of solar-fiare ionizing radiation on weather, the literature abounds with a wide variety of lomger-term correlations of terrestrial weather with the 11-year sunspot cycle and the 22-year double-sunspot cycle. The major cyclic periods claimed in the literature are: 27 days, 11 years, 20 years, and 22 years. Most of these claimed correlations are weak and have been hotly debated. Often they have been rejected as statistical flukes.

The physical mechanisms underpinnning the several proposed correlations are usually unspecified. Sunspottery, as it used to be called, is mainly a statistical game of sorts. To make matters worse, some of the statistical methods employed sometimes introduce false periodicities. Beat frequencies have also been proposed.

Background. Ever since the sunspot cycle was discovered, it has been correlated with various natural phenomena including human activities. Wide extremes of opinión have been expressed from blind-faith in a sun-weather connection to out- right ridicule and strong declarations that no physical mechanisms exist that could possibly connect the solar activity to terrestrial weather. Not surprisingly, the pertinent literature is extensive, and it is only sampled here.

Even after about 150 years of statistical study, most meteorologists remain unconvinced that there is a significant solar-activity effect on the earth's weather.

Data Evaluation. Century-long stretches of sunspot counts and abundant data on various terrestrial phenomena are buried in the archives of Science. Statisticians have much to chew on. Actually, their sun-weather correlations can be rather impressive for very specific, usually short, time periods and limited geographical areas. But the correlations are often clouded by high noise levels, the super- position of several periodicities, including lunar modulation, and the improper use of statistics. Rating: 3.

Anomaly Evaluation. Scientists have proposed a few physical mechanisms that might link solar activity to terrestrial weather (see below), but their efficacies have not been demonstrated convincingly. The repeated appearance of a 20-year cycle-----rather than 22-years---------in soroe terrestrial weather phenomena might be solar-induced but there do not seem to be any robust solar phenomena exhibiting a 20-year cycle. In view of science's emphatic and usually justified dismissal of the mountains of published correlations, the actual appearance of any strong sun- weather correlation, backed by a reasonable physical mechanism, would be an important anomaly. In other words, the ruling paradigm is no significant sun- weather effect. Rating: 2.

Possible Explanations. Solar-wind periodicity, cyclic variations in solar heating of the earth, solar tides in the earth's atmosphere.

Similar and Related Phenomena. Weather correlated with lunar phase (GWS1); weather correlated with planetary configuraron (GWS8); solar activity correlated with thunderstorm frequency (GWS3); solar cosmic rays correlated with lightning (GLL16 in Remarkable Luminous Phenomena...).

Examples of Correlations between Solar Activity and Weather

XI. 1859. Worldwide phenomenon. "M. Rudolph Wolf of Berne has shown that those years remarkable for abundance of solar spots have also been more than commonly rich in aurorae boreales. The greal auroral display at the commencement of September 1859, occurring about the time for the re- turn of sun-spot máximum, and which seems to have been visible over the greater portion of both hemispheres, appears to have been the precursor of a great meteorologicaldis- turbance: in England and Northern Europe more than an average amount of coid, wind, and rain have prevailed ever since; inNorth America and India more than an average amount of drought and heat. The opinions of philosophers differ respecting the influence of a paucity or an abundance of solar spots upon the temperature and seasons of the earth; the probability is, there is simply a general disturbance, arising from increase of (solar) magnetic influence, which may produce greater heat and dryness in one part of the globe, and more coid and rain in other parts. " (Rl) These general thoughts about the sun-weather effect can hardly be made much more specific today, even after well over a century of correlations and more sophisticated research. See the recent skeptical opinions expressed in later entries.

X2. Stalistical analysis. A presentation of tables of rainfall data from 18 stations at various localities around the world for different spans of time. "The above Table comprises the results of all the rainfall- tables I can find containing a maximum- and a minimum-period. Now we see that, in the máximum-sunspot periods of three years each, the rainfall at the eighteen stations was 395. 85 inches greater thanin the minimum-sunspot periods of three years each, and, which is still more stri- king, that the excess is on the side of the maximum-periods at fifteen out of the eighteen stations." (R2) At this point in history worldwide weather data were almost nonex-istent, and the studies were necessarily crude by modern standard?. (WRC)

X3. General observation. Comment6 on an article in the London Times linking the Indian famines (droughts) with the sunspot cycle. In essence, the whole idea is "absurd and ridiculous." (R3) Similar disdain is still expressed today.

X4. Statistical analysis. Worldwide data. "The idea that years of máximum sunspots are also years of abundant harvests, origi- nally suggested by Sir William Herschel, has lately been brought into prominence through the labours of Mr. Meldrum, of the Mauritius, whose 1 atest paper on the sub- ject, published in the monthly notices ofthe

Mauritius Meteorological Society, gives figures based on the rainfall staiistics of a large number of stations in different parts of the world. These seem to show thatthe average rainfall of the globe is subject toa regular fluctuation through periods of about 11 years, and that at its máximum, which occurs about a year later than the epoch of máximum sunspots, the mean fall is about 15 per cent, greater than at its mínimum, which precedes that of mínimum sunspots by one or two years. " (R4, R5) Meldrum's careful analysis was an early benchmark in sun-weather analysis. (WRC)

X5. Historical review. Sir William Her- schel's 1801 papers on a possible con- nection between the solar cycle and our weather are resurrected. Long quota- tions from Herschel's papers revealthat he proposed that variations in the quantity of solar heat reaching the earth might contribute to the cyclic variations in weather. (R5)

X6. General observations. A rambling dis- sertation on how the sunspot cycle might af- fect both terrestrial weather and human activities. Written in memory of Stanley Jevons, an early and prolific proponent of "sunspottery. " The only pertinent data are the following observations, which arefairly typical of 1883: "Of late years the rainfall of the British Islands has become an object of special study and investigation, with ama- teurs as well as paid officials. Mr. J. J. Symons, of the Meteorological Society, who has recently published statistics gathered from numerous quarters, takes occasíon to refer to the existing caprice of heaping ridi- cule on the astronomical precedent of refer- ring the phenomena of Nature to fixed and pre-determinate laws. He calis attention to the circumstance that the wettest years in England of late prove to have been 1836, 1841, 1848, 1852, and 1860, and that the first, third, and fifth of these years fall into a twelve-year period. He further calis attention to the circumstance that the driest years in England of late prove to have been 1826, 1834, 1844, 1854-5, 1858, and 1864, and that the second, third, fourth, and se- venth of these fall into a ten-year period. Now it is at once manifest that the twelve- year period of wet years he here indicates coincides with the solar cycles, and that the dates only differ by two years on the whole from the epochs of most sun-spots assigncd by Prof. Wólf. The ten-year period of dry years, which altemates with these wet years, which then consequently corres- pond to the mínima years of solar spots, from which in three of the instances they differ but one year. " (R6)

X7. Statistical analyses. Following a short history of sunspot-weather correlations, a statement by Arthur Schuster, "There can be no longer any doubt that during about four sun-spot periods (1810 to 1860) a most remarkable similarity (existed) between the curves representing sun- spot frequency and the curves of nearly every meteorological element which is related to temperature.
This is not, in my opinión, a matter open to discussion: it is a fact. But it is equally certain that during the thirty or forty years previously to that time so such relationship existed, and that since 1860 the connection has again in some instances become less distinct." "In so far as regards the temperature of the globe, these conclusions are almost identical with those enunciated by Prof. Koppen, in a paper published in the April-May Heft of the Austrian Meteorological Zeitschrift for 1881, and indeed the ap- parent discrepancy of the temperature and sun-spot curves after 1858 had been indica- ted by him in his former paper, published eight years earlier. But this discrepancy did not set in simultaneously in different parts of the globe, ñor has it been such as to oblitérate all trace of the sun-spot cycle in the temperature curves. During about four cycles previous to 1858, the tempera- ture of the tropical zone rose and fell with somewhat striking regularity inversely as the spotted surface increased or diminished, so that the highest temperatures approxí- mately coincided with the sun-spot minima, and the lowest with their maxima." (R7) Almost a century ago the complexity oí the sun-weather relationship was appreciated, as correlations waxed and waned. (WRC)

X8. Statistical analysis. Scotland. An un- broken series of rainfall data from 1800 shows good correlation with the sunspot cycle. (R8)

X9. Statistical analysis. Jamaican rainfall data from 1870-1910. "Excepting the rainfall mínimum in 1875 the minima for rainfall follow solar máximum and mínimum by one and a half or two years. The rainfall máximum between the mínimum are more irregular." (R9) Spelling is as in the original article.

X10. Statistical analyses. Christiania, Nor- way, and Greenwich, England. Mean temperatures for both locations show

strong correlation with the sunspot cycle. (RIO)

Xll. 1911. Opinión ventured that the unusual diminution oi ultraviolet radiation from the sun caused an extremely dry summer Ln Europe and a very wet winter in South America. Fewer condensation nuclei thought to be the underlying reason. (Rll)

X12. Statistical analysis. Moctezuma, Chile, and Washington, DC. "Regular observations of the sun's radiation are made from a sta- tion at Mount Montezume, Chile, a mountain 9, 000 feet high in the Atacama desert, and these show that the sun does not always radíate the same amount of heat. Instead, it varíes from day to day, even after allowances are made for the effect of the earth's atmo- sphere. In a study of these variations since January, 1924, Dr. (C. G.) Abbot has found 98 cases of rapid increase of the radiation of heat and 91 of decrease, in each case the change taking about four or five days. Dr. Abbot has studied the temperature variations at Washington at the times of each of these increases and decreases. Taking the temperature just before the beginning of the solar change as normal, he finds that as the solar radiation varíes, the temperature also chan- ges, and that the change in temperature continúes until at least four days after the máximum or mínimum of radiation. A change in the radiation of eight-tenths of a per cent is accompanied by a temperature change of about five degrees. At times when increase of radiation is accompanied by an increase in temperature, a decrease of radiation is generally accompanied by a decrease in temperature. This is taken by Dr. Abbot as rather conclusive proof that the change s are not mere coincidences. A curious fea- ture of the results is that an increase of radiation is not always accompanied by an increase in temperature, or vice versa. " (R12)

X13. Statistical analysis. Egypt. Flood and low stages of the Nile. "A remarkable series of yearly records of high and low levels of the Nile at the Roda gage, Cairo, from 622
A. D. to 1470 has been published by Prince Ornar Toussoun. The original records are in cubits and dated in Mohammedan years. One list from 640 to 1451 was published in 1923. Another list from 622 to 1470 in metric equivalents and corrected to the modera cal- endar was published in 1925. These two lists differ slightly and after careful exami- nation of the graphs of both lists it was de- cided to use the first one, making a fewcor- rections to readings, evldently misprints, by comparison with the laler list and supplying a number of missing years. Five-year means have been computed for both flood and low stages. The 11-year period. The influ- ence of the 11-year solar period on the flood stages is shown by an excessive predomi- nance in the 5-year means of the two intervals, over the normal frequency for random num- bers, 50 percent vs. 40 percent. As for the mínima there is a relative excess of the four- and five-intervals, indicating a 20- to 25-year period. " Longer periods evident in the analysis are 37, 83, and 300 years. (R13)

X14. Statistical analysis. Severe winters in Europe. "Records of unusual meteorological events are abundant in European literature. The occurrence of severe winters has been very consistently recorded, and Bruckner, by means of this material, was enabled to extend his 35-year cycle, deduced from modera instrumental records, back to the year 1000.....To extend the series back-ward, I have used Hennig's catalog which is very complete. Easton's list was also con- sulted. Employing the method used by Bruckner, the total number of severe winters in the 20-year interval centered on every fifth year were counted and the numbers from 340 to 1030 together with his numbers from 1030 to 1775 are shown graphically... .The 37- year period. Maxima and mínima are quite definitely apparent except in a few instances where data are lacking." There are indica- tions of 83- and 300-year periods, too. (R13)

X15. Statistical analysis. Wheat prlces in England. "In a paper published after his "Klimaschwankungen", Bruckner concluded from an examination of wheat prices in western Europe for 200 years that high prices occur during or shortly after periods of máximum rainfall. Beveridge computed yearly índex numbers of wheat prices in England from 1500 to 1870 by expressing them as a percentage of 35-year moving averages. His periodogram of wheat prices shows a period of considerable amplitude at 35.5 years." (R13)

X16. Statistical analysis. Tree growth in Arizona and California. Measurements of tree growth rings in California (sequoias) and Arizona (yellow pine) demonstrated the existence of climatic periods of 37, 83, and 300 years. (R13)

X17. Statistical analysis. Levels of the Great African Lakes, 1900-1930. "In 'The Rydrology of Lake Tanganyika'_____C. Glll-man gives us for the first time a picture of the fluctuations in level of Lake Tanganyika. To it he adds C. E.P. Brooks's curves of

Victoria and Albert and F. DLxey's ofNyasa, brought up to date, and the curve of sunspot numbers, Excepting the abnormality in Nyasa dating from the closing of the Shire outlet (1924), the trends of the lake fluctu- ations are similar and the correlation with the sunspot curve cióse. Mr. Gillman, how- ever, cautions against too facile an inter- pretation. He points out that in 1929 when Victoria, Albert, and Tanganyika were at a distinct low, sunspot numbers soared, and when in 1930-1931 the numbers declined, there was a rise in lake level. Before 1902 also Victoria seems to have 'reacted incor- rectly. ’ While we are still far from a solu- tion of the problem, much is to be hoped from simultaneous study of all four lakes, with their broad regional similarity and their individual differences. " (R14)

X18. Statistical analysis. Greenwich, Eng- land. The sunspot cycle is barely seen in 100 years (1764-1863) of mean tem- perature data from Greenwich. (R15)

X19. Study of post-Pleistocene climates. Abstract. "The most conspicuous climatic aberration of the past two millennia was the temperature decline and glacial advance of the A.D. 1550 to 1900 period. This temperature decline has been correlated with an interval of lower solar activity and there is evidence from both the post-Pleistocene glacial record and from oxygen-18 analysis that such an interval has recurred at cyclic periods of around 2400 to 2600 years. " (R16)

X20. Statistical analysis. "...two investi- gators, Walter Orr Roberts, president of the University Corporation for Atmospheric Research, and Roger H. Olson, an Environ- mental Data Service research meteorologist with NOAA, appear to have confirmed a statistical relationship between the behavior of certain atmospheric features over the Gulf of Alaska and geomagnetic storms. Appar- ently, low-pressure troughs found at the 300-millibar level tend to intensify ordee- pen, in response to storms in the geomagnetic field, which are marked by displaysof auroras. Trough development in that geo- graphic area has an important influence on North America's weather. About one-third of the Gulf of Alaska'a low pressure Systems eventually move into the central United States. Those preceded by northern lights pene- trate about 200 miles farther south, and bringcoolerweatherwith them. Although not all large troughs are triggered by northern lights and not all auroras are followed by trough development, the probability of the trough's intensifying seems to be approx- imately doubled by the occurrence of a mag- netic storm .....Still, the results of the en tire study are perplexing to the scientists because there is no proven physical explanaron for them. Regarding mechanisms to explain the findings, they speculate that the geomagnetic control may come about through trapplng of the black-body radiation normally lost to space over the relatively warm Pacific during these winter months. This could be the result of cirrus cloud formation by phenomena associated with the geomagnetic disturbance. Other alternative explanations may involve changes in ozone content, and possibly increased thunderstorm activity. " (R17) ‘

X21. Statistical analysis. Tree ring data from the western United States from 1700 to date. "No evidence was found for any influence of the 11-year cycle, but there is a very strong match between periods ofdrought and the 22-year double sunspot cycle (the Hale magnetic cycle). The area covered by drought tended to reach a máximum about 3 years after every other mimmum in the 11- year cycle, with the most recent well-docu- mented drought being that of the mid-1950s, correlating with the sunspot minimum of 1954. (The drought of the 1970s seems to be correlating with the sunspot minimum of 1976.) The time between droughts averaged 20.4 years, whereas tht average double sunspot cycle is 22 years. The reason for this apparent discrepancy is that the best coherence between drought area and sunspots comes during times when the sunspot maxima are high. It is during such periods that the time between successive maxima and mínima tends to be smaller. When the sunspot numbers are small, the period of the cycle increases, and the correlation with drought area becomes weak. " (R18) These data hardly support those of X16. (WRC)

X22. Review paper. Several studíes now confirm a solar influence on atmospheric circulation at the 300 millibar level and below. The passage of solar-sector boundaries seem to affect the vorticity of the atmosphere. (R19)

X23. Review of a lecture by J. W. King of the Appleton Laboraloiy. ".. .the new work from the Appleton Laboratory concéntrales instead on much shorter term influences, associated with the roughly 27.5 d rotation period of the Sun. The 'signature' oí this rotation shows up clearly in such meteoro-

logical parameters as the height of the 500 mbar pressure leve] in the atmosphere, as well as iníluencing ionospheric properties. In some danger of numbing his audience with overkill at times, King hammered home the reality of these links with a wealth of data, the most intriguing of which showed clear geographical variations of the magnitude and even sign of the atmospheric changes produced by the Sun. Small wonder, then, that global averages over long periods show much less indication of any solar influence on weather!.... The Appleton team have now found that not only does a solar fiare produce a disturbance of the atmosphere, commencing some four days after the fiare, as shown by the work of Olson and others, but that the atmospheric disturbance is re- peated at 32 and 60 days as well, one and two solar rotations later. In at least one case, an effect on the atmosphere is also found at -24 d, that is one solar rotation before the fiare became apparent. So a spe- cific región of the Sun which is involved in some disturbance can affect specific regions of the Earth's atmosphere over a period of 2-3 months----and, equally, the effects of solar activity which are disturbing the atmo- sphere today musí be the integrated effects of several such past disturbantes, which suggests that we should not fínd any simple relation between what the Sun is doing today and what the atmosphere does tomorrow. " (R20) But see the following entry. (WRC)

X24. Summary of the Ohio State University Sun-Weather Conference, July 24-28, 1978. Many of the presentations were skeptical of the reality of any sun-weather effects, as typified by the following: "The chief skeptic by far, was A. B. Pittock, temporarily of the University of Arizona. He cast strong doubts on many published reports of corre- lations between weather and the various solar cycles (such as 27 days, 11 years and 27 years). The 27-day cycle was also attacked by others, who pointed out that it is difficult to distinguish between 27-day solar and limar effects." (R21)

X25. Review paper. Abstract. "During the past century over 1,000 articles have been published claiming or refuting a correlation between some aspect of solar activity and some feature of terrestrial weather or cli- mate. Nevertheless, the sense of progress that should attend such an outpouring of 'results' has been absent for most of this period. The problem all along has been to sepárate a suspected Sun-weather signal from the char- acteristically noisy background of both Systems. The present decade may be witnessing the first evidence of progress in this field. Three independent investigations have reveal- ed what seem to be well resolved Sun-weather signáis, although it is still too early to have unreserved confidence in all cases. The three correlalions are between terrestrial climate and Maunder Minimum-type solar activity variations, a regional drought cycle and the 22-yr solar magnetlc cycle, and winter hemisphere atmospheric circulation and passages by the Earth of solar sector boundaries in the solar wind. The apparent emergence of clear Sun-weather signáis stim- ulated numerous searches for underlying causal links." (R22)

X26. General observations. "There is a general consensus among meteorologists and climatologists that for reasons unknown to them, quiet Sun produces severe winters whereas the appearance of colder sunspots on the solar disk produces warmer winters on Earth. Severe winters appear to correlate well with the solar cycle. There is also evidence of enhanced cloud cover and thunder- storm activity, and anomalous rainfall pat- terns which follow solar fiare and auroral activities. To explain some of the features, physical mechanisms based on changes inthe character of solar particulate and electro- magnetic radiatlon and their interactions with the Earth's atmospheric, hydrospheric and magnetic envlronment were proposed in an earlier paper. This hypothesis is further advanced to explain the anomalous rainfall pattern, i.e. increased rainfall at 55°N and reduced rainfall at 35°N latitudes following solar fiare activity. The explanation involves interaction between descending streams of charged partióles with global circulations in the presence of Earth's magnetic dipolar field whose axis does not coincide with Earth's North-South geographic axis. " (R23)

X27. Statistical analysis. "In a recent paper, Nastrom and Belmont have found an interesting correlation between the 11- year sunspot cycle and the upper troposphere and lower stratosphere. They have thorough- ly and carefully analysed data from the Northern Hemisphere for a period covering 1949 to 1973, i.e., just over two solar cycles. Their results indícate that during the winters of this period, the average position and, to a lesser extent, the strength of the jet stream and the intensity of features such as the Si- berian upper level trough, have a strong correlation with solar activity. It is not so much the statistical significance of the results which is surprising, but rather that in cer- tain areas of the hemisphere 50% of the inter- annual varlance is explained. " (R24)

X28. General observation. "Despite almost 180 years of study, we have little evidence to support the hypothesis that solar activity significantly affects the troposphere. There is a plethora of statistical correlations, but many of these have been produced by over- filtering and selecting the data and the re- mainder have nearly all failed where the data sets have been extended in time." (R24) This comment of course applies to correlations with lunar phase.

X29. Statistical analysis. After noting that climatic oscillations with a period of about 20 years have been detected in U. S. midwest drought records, dendrochronological data, and sea sur face temper ature anomalies, the authors present their studies of Greenland ice core records. "To gain more insight into such 20-yr oscillations, we have examined characteristic oscillations in Greenland ice core oxygen isotope records. The resulte show that the strongest spectral peakoccurs at a period of 20 i 0. 5 yr with a statistically significant amplitude. This. period is essen- tially the same as that found in eastern North American winter temper atures. More- over this 20-yr oscillation is found to be co- herent in peíase with the dominant variation in the Sun's motion about the centre of mass of the Solar System. This motion has been hypothesised to be closely linked with sun- spots. On the basis of these observations we speculate here that a 20-yr oscillation may be a more fundamental solar and/or climatic oscillation than the nominal 22-yr cycle often mentioned. " (R25)

X30. Statistical analysis. Abstract. "July Palmer Drought Severlty Índices (PDSI)have been reconstructed for the Hudson Valley región of New York State from the annual ring-width variations of local oíd trees.

Using addltional, subsequently developed tree-ring chronologies, we have developed a new July drought reconstruction that ex- tends back to 1694. Variance spectra ofthe new PDSI series reveal statistically slgnifi- cant quasi-perlodicities of 11.4 and 26 yr. (R26) The 11.4-year period is, of course, cióse to that of the sunspot cycle, whilethe 26-year period correlates with the soli-lunar tidal period.

X31. Statistical analysis. Leona M. Libby and colleagues at the Unlversity of California at Los Angeles have found periuds of 10.4 and 6. 7 years in sequoia tree rings dating from 2,000 years ago, using isotopic measurements as indicators of temperature. There was, however, no trace of the 21-year solar magnetic cycle. (R27)

X32. Statistical analysis. Studies of North American temperature records by Robert Currie, Goddard Space Flight Center, reveal the 11-year sunspot cycle to be present in temperature data east of the Rockies and north of about 35°N. The winds in this región are part of the circumpolar vortex that helps determine the climate of the earth. (R27)

X33. Statistical analysis. "In 1980, Minze Stuiver of the University of Washington compared ten different records of climate from around the world with the varying carbón-14 content of tree rings over the last 1000years; carbón-14 is an indirect measure of changing solar activity. Stuiver failed to find a significant correlation between solar activity and any of the climate records." (R28) Obviously, conflicting results, such as this and X30-31, make for a muddled picture and undermine confidence in the reality of solar influence. (WRC)

X34. Statistical analysis. Records of drought from the American west, added to newly obtained data from the Great Plains, show the 22-year solar magnetic cycle very strongly-----at a high level of signifieance. (R28) '

X35. Statistical analyses. Examination of drought records from the American west (X34) seem to show that in addition to the the 22-year solar magnetic cycle there exists a 18.6-year effect of lunar tidal action. These cycles are superimposed on one another, making a most confusing situation. (R29)

X36. Statistical analysis. 1784-1869. A positive correlation was found between the sunspot number are: March-April rainfall in France; arrivals of birds in France; thickness of annual growth rings in sequoias; commodity prices in Great Britain and Ireland; and auroral frequency. (R30)

X37. Statistical analysis. A review of studies of tree-ring growth cycles. Concluding state- ments. "In a general way it is safe to say that the sunspot cycle and its double and triple valué are very general. The double valué has persisted in Arizona for five hundred years and in some north European localities for the century and a half covered by uur tree groups. The triple period, essentially Bruckner's cycle, has operated in Arí?.<>na for the last two hundred years and in N<.r- way for four hundred at least. A hundíed- year cycle is very prominent throughout the three thousand years of sequoia records and

also Ln the five hundred years of yellowpine.
It is still uncertain whether the eleven-year cycle can be judged by the variations in its double valué, which, from the absences of certain interfering periods, is more easily traced through long periods. But a very incomplete review of the sequoia record sug- gests that from 1300 B. C. to well after 1000
B. C. the eleven-year cycle was well devel- oped; then it slowly decreased. From 300 B. C. on it was increasing and was very con- spicuous during the first two centuries of our era. Then it decreased, and from 400 to 650 A. D. was only occasionally evident. From 650 to 850 or 900 it seems fairly con- tinuous. Then it appears only occasionally until about 1250, when it again becomes fairly continuous, except for the changes in the seventeenth century above noted. "
(R31)

X38. Statistical analysis, 1871-1973. New York, New York. The January mean temperatures show a strong 20-year cycle. (R32)

X39. Compilation of statistical coefficients. During the 1920s nnd 1930s, H.H. Clay- ton collected a large body of statistical evidence for the existence of causa] links between solar activity and various terrestrial weather phenomena. In this paper (62 pp. long), he presented a summary table of 20 such correlation coefficients between solar activity and a rather disparate group of weather data collected from many weather stations.

For example, the first six table entries presented coefficients "Between monthly mean temperature 0 to 4 months succeeding high and low months of solar radiation of the years 1905 to 1925 from stations at Nome, Juneau, Edmonton, St. Johns, Hatteras, and Key West." The table continued with similar rather ob- scure relationships.

Clayton justified this sort of narrowly focussed statistical approach with:

"As it has seemed to me that hereto- fore critics have been apt to overlook many of the evidences favorable to solar variation and its influence on weather, perhaps because these were too numer- ous and extensive to be mentally di- gested."

Remember that a significant sun- weather relationship was generally denied by meteorologists at this time, and Clayton was fighting an uphill batlle.
In truth, though, Clayton's 20 sun- weather "connections" are too fragmented to be very convincing.

See X41 for another similar paper in this long series of studies by Clayton.

X40. A 1933 summary of sun-weather connections. In 1933, C.G. Abbot was secretary of the Smithsonian. He was also deeply immersed in attempts to correlate solar activity and terrestrial weather. Abbot also supported Clayton's studies described in X39 and X41.

In the present paper, Abbot presents four major conclusions he had arrived at during his personal studies of the sun- weather connection. The first two of these conclusions are recognized as potential, probably minor, contributors to terrestrial weather by today's meteorologists, but they weren't in Abbot's day.

"1. The principal departures from normal climates which comprise 'weather' are due primarily to a group of periodic variation's of the sun's radiation rather than to terrestrial complexities as has been generally supposed.

"2. Sunspots are associated with important modifications of weather not hitherto recognized.

"3. Important periodieities in solar variation have their least comraon múltiple of 23 years. As a consequence, weather repeats itself in all parts of the world with 23-year intervals...

"4. At many stations this cycle in weather enables us to forecast general conditions of temperature and precipita- tion for many years in advance..."

Conclusions #3 and #4 are not ac- cepted today, especially #4.

X41. OverView of world weather and solar activity. In the sixth of a series papers supported by the Smithsonian,
H.H. Clayton stressed three general observations.

"1. The world-wide correlations of atmospheric changes, as indicated by a similarity in these changes in both the Northern and Southern Hemispheres and in widely separated continente and oceans. In some cases the changes are directly similar, and in others the changes are directly opposite----------that it, when one increases the other decreases.

"2. A relationship is found between atmospheric changes and sunspot activity, and an even closer relationship with changeB in solar radiation.

"3. Centers of action in the atmo- sphere are found to shift position uner the influence of changes in the intensity

of solar activity_____" (R37)

Modern meteorologista probably see much that is naive in the above aBser- tions!

X42. Statistical analysis. Circa 1945, C. G. Abbot, in a 44-page paper, Bet down 18 key observationB supporting his hypothesis that terrestrial temperatures depended upon variations in solar radia- tion. For a sample, we quote from his number 5.

"Main results : Solar changes affect weather for about 20 days; produce major effects on temperature which are generally opposite for rising and falling solar activity; and may alter tempera- tures by 10° to 15° F. as much as 10 days after the zeroth day, depending on whether the solar radiation has in- creased or decreased." (R38)

X43. Sunspots and Canadian weather. In 1936, A. Thomson downplayed the use- fulness of sunspots in weather forcasting.

"Variations in the period and ampli- tude of sunspot fluctuations are so great that that the number of sunspots present a year or so in advance cannot be ac- curately forecast. Henee seasonal weather fprecasts based on sunspot numbers are unreliable." (R39)

An obvious blow to believers in a strong sun-weather connection and the usefulneess of sunspots in predicting weather..

X44. Statistical analysis. Sunspots and Canadian weather. Thunderstorm fre- queney and temperature at Toronto are inverse to the sunspot eyele. In general, however, correlations of sunspots with Canadian weather are not straightforward.

Again, only a highly focussed corre- lation had been found amidst confusing data from elsewhere.

The author of the referenced paper, R.E. De Lury, made an interesting com- ment regarding precipitation and Canadian geography.

"Investígation of the sunspot influ- ence on precipitation has led us to what is considered to be a fundamental con- cept, namely, that there are two ideal responseB to the sunspot eyele, the one an oceanic or aquene response, the other an inland or terrene response, the for- mer in direct phase, with the sunspot eyele and the latter in inverse phase." **(R40)**

Why these two effects exist was an unanswered in 1938. In fact, we never see the words aquene and terrene in the modern literature.

Interest and research in "sunspottery" and weather declined during World War II. Our files are empty from 1938-1976!

X45. Statistical analysis. Eastern North American temperature records. Roughly four decades after the Smithsonian and Canadian studies, statistical correlations again became fashionable. S.J. Mock and W.D. Hibler examined the temperature records from 19 stations in eastern North America from their beginning up to 1974/1975. Many of the records are over a century long. They reported the following.

"It has been argued that there is little or no reliable evidence for 11- or 22-yr eyeles in meterological time series, and that even if a spectral peak existe, the identified eyele may not maintain its phase and amplitude sufficiently to allow prediction. To investigate this we have examined January temperature records for 19 stations in eastern North America. Our results show that: fírst, a pervasive 20-yr peak exists in the spectra of January temperatures in eastern Cañada and the United States; secondly, the 20-yr oscillation was largely in phase over this región until approximately 1960; and thirdly, the predictability of this oscillation is, at best, only marginal." (R41)

Two points of interest here are: (1) the eyele is 20 years long, far short of the double-sunspot eyele; and (2) the implied loss of phase after 1960. What happened then?

X46. Sun-weather eyeles and autosug- gestion. A.B. Pittock, in a 1978 sympo- sium presented a rather unflattering review of past studies of the frequently claimed influences of sunspots on the earth's weather.

"It is concluded that despite the great number of papers on the subject, little convincing evidence has been pro- duced for real correlations between sunspot eyeles and weather or climate, al- though evidence of correlations between weather and solar events on time acales of days appears to exist. The conclu- sions tend to support Monin's impression of successful experimente in autosugges- tion and Gould's recent suggestion that unconscious manipulation of data may be a scientific norm." (R42)

In essence, Pittock opined that many sun-weather researchers were seeing only what they wanted to see in their data!

X47. Solar electrifcation of the earth's atmosphere and weather. R. Markson BUggested in a 1978 issue of Nature (273:103) that variations in solar radia- tion might modify the eleetrical structure of the earth's atmosphere in ways that could account for aome of the many published sun-weather correlations.

Finally, someone was proposing a physical mechanism that might explain some of the correlations--------an element sadly lacking in the sun-weather studies.

L.C. Hale, however, asserted that available evidence did not support Markson's suggestion, especially in the matters of ionization levels and the 1979 models of the atmosphere's eleetrical structure- (R43)

In a companion letter in Nature, Markson answered Hale's objections, adding:

"An attempt to explain solar-weather relationships as due to ionospheric and magnetospheric eleetrical processes is understandable, however, these do not seem applicable to the problem. Upper atmospheric cúrrente and partióles would introduce energy into the atmosphere orders of magnitude too small to affect weather processes." (R43)

In other words, correlations of terrestrial weather with solar activity probably cannot be explained by the impact of the sun's particulate radiation on atmospheric electricity!

X48. Statistical analysis. See: GWS1-X33.

X49. The sun and global warming. In 1984, Arctic and Antarctic temperatures warmed in step------a strong sign of global warming. Some scientists saw these observations to be the consequence of "the internal complexities of the global climate system;" that is a purely terrestrial phenomenon. It was, nevertheless, admitted that changes in solar activity might be in volved. (R45)

X50. Statistical analysiB. North American Corn Belt. See results in GWS1-X36. (R46)

X51. Statistical Analysis. North American Corn Belt. See reults in GWS1-X37. (R47)

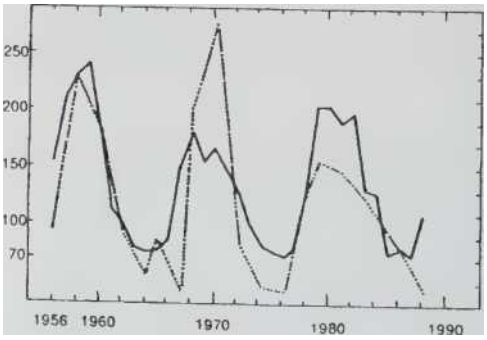
X52. Statistical analysis. In the middle 198Os, meteorologists in general had concluded that the many proposed links between solar activity and terrestrial weather-----such as cataloged here in XI-X51----were unconvincing and revealed no significant cause-and-effect relationship.

But in 1987, K. Labitzke at Berlin's Free University was struck with the idea that perhaps the oft-proclaimed but widely doubted solar-weather connection might show up clearly only under special conditions.

The special condition chosen for analysis by Labitzke was the QBO (Quasi-Biennial Oscillation). The QBO is a period that occurs every 2 or 3 years when the wind in the equatorial stratosphere reverses its direction. [We do not know her reasons for selec- ting this obscure phenomenon.]

"It suddenly occurred to her to plot on one graph the wintertime temperature at about 23 kilometers over the North Pole during west equatorial against sun-spot number.____When Labitzke plotted only pole temperatures from the QBO's west phase, a strong correlation became clear."

Labitzke's correlation was so strong that many long-time doubters of such sun-weather correlations were impressed. However, a physical mechanism for the correlation was not apparent. How could the weak solar-cycle variations, which were observable mostly in the ultraviolet and affected only the earth's thin stratosphere, trickle down and perturb the much more massive troposphere. (R48)



Example of a claimed strong correlation in time between a measure of solar activity (left ordinate, dotted Une, solar 10.7-cm flux) and the temperature in the North Pole stratosphere (right ordinate, solid line, in ***°C) . (X52)***

X53. Statistical analysis. A 1987 Science News story covered Labitzke's discovery and supporting work by H. van Loon. Even though Labitzke's correlation was strong, meteorologista still had reserva- tions. Some of these reservations were doubtless based upon the "disreputable" past history of sun-weather correlations. Van Loon himself remarked: "This is purely statistics, and we don't under- stand the physical mechanism. Unti] we understand it, we should not use statistics to form predictions." (R49)

X54. Statistical analysis. In the Septem- ber 8, 1988, issue of New Scientist, van Loon and Labitzke collaborated in writing a popular account of their work mention- ed in X52 and X53. Their article ended with another warning.

"Our analyses are nothing more than statistics. We can only be sure that we are right if someone can explain how such a large influence on the atmosphere can be produced by comparatively small changes in the energy output of the Sun during the solar cycle." (R50)

X55. OverView of the reception of the Labitzke correlation. Toward the end of 1988, the sunspot-weather connection proposed by Labitzke was still holding up but still unexplained physically. Its long survival surprised the many skeptics who were sure that it was just a fluke and would soon go away! (R51)

X56. Statistical analysis. Labitzke's work was supported in 1988 by some data published by B.A. Tinsley. He showed that the storm tracks in the North Atlantic Ocean were anticorrelated with the solar cycle only when the QBO (Quasi-Biennial Oscillation) was in its west phase. (R52)

The Sourcebook’s sweep of the liters- ture is fairly broad, but we have found no further discussion----------positivo or nega-tive-----of the Labitzke correlation. It must be noted, though, that this correlation, if it is sustained, is very nar- row in its scope. The sun's impact on terrestrial weather, if it really exists, is slim and spotty.

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GWS6 The Influence of Lunar Phase on Atmospheric Ozone

Description. The apparent increase in the amount of atmospheric ozone at the vernal equinox about the first and third lunar quarters, with a corresponding descrease at the same phases at the autumnal equinox.

Data Evaluation. A single study with data from only two stations. Rating: 3.
Anomaly Evaluation. The mechanism by which the moon's position could influence the pro- duction of atmospheric ozone is a mystery, and there are few obvious candidates considering our present knowledge of geophysics and astronomy. Rating: 2.

Possible Explanations. Since the lunar effect appears when the earth crosses the plañe of the ecliptic, one suspects a lunar shielding of the earth from some ozone-producing mechanism confined to that plañe.

Similar and Related Phenomena. Lunar phase correlated with thunderstorms (GWS2); lunar phase correlated with rainfall (GWS1).

Examples of the Influence of Lunar Phase on Atmospheric Ozone

XI. Statistical analysis. "Abstract. Evidence is presented for a lunar effect on the amount of atmospheric ozone at Arosa in Switzerland and Canberra in Australia. The amount of ozone increases at the vernal equinox about the first and third lunar quarters and decreases at the same lunar phases at the autumnal equinox. There is no effect at mid-winter or midsummer. The explanation of this limar effect is unknown, and further in- vestigation is needed. " (Rl)

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GWS7 The Lunar Temperature Effect

Description. Near the time of the full moon, the increase in polar air temperatures over those prevailing at the time of the new moon. At mid-latitudes, the effect is reversed, while in the tropics the effect is negligible.

Data Evaluation. The older literature provides some striking examples of the lunar effect at several, but not all, mid-latitude stations. Modern satellite instruments reveal a full-moon, polar-air warming and also confirm the mid-latitude depression of temperature mínima. Rating: 2.

Anomaly Evaluation. The lunar tidal action on the earth's atmosphere and the earth's closer approach to the sun at the full moon are possible warming mecha- nisms, but they would not not account for the mid-latitude cooling at full moons. Rating: 2.

Possible Explanations. See above.

Similar and Related Phenomena. The moon's effect on the weather (GWS1); on thunderstorms (GWS2); on atmospheric ozone (GWS6), and on cloud cover (GWC11).

Entries

XO. Introduction. Given the moon's small size, great distance from earth, and coid surface, one would not expect it to have any influence at all on the earth's temperature. But our file on this subject reveáis an "oíd" series and a "new" series of terrestrial temperature observa- tions that belie our expectations and perplex scientists.

The "oíd" series began in 1857 and was still under discussion as late as 1953. Our file indicates that the "new" series did not begin until 1995----------42 **years later. Curiously, the "new" series never mentions or referenceB the "oíd" series!**

The full moon is the "forcé," rather the indicator of some unperceived influence or mechaniBm, in both series.

In the "oíd" studies, this full-moon "forcé" UBually depressed average mínimum temperatures at various mid-latitude ground stations; while the full-moon influence in the "new" studies, as measured by satellites, correlated with a slight elevation of average máximum polar temperatures! The satellites also con- firmed a dip in mid-latitude temperature mínima seen in the "oíd" series ground- based data.

When reading the eleven referenced papers, it is apparent that the lunar effect on earthly temperatures is com- plex. It varíes geographically and is not always punctual when the full moon rises! (X5) At some weather stations, the effect is completely absent in the "oíd" series. (X5, X6)

Below: "oíd" studies: X1-X8; "new" studies: X9-X10.

XI. Statistical analysis. A period piece. "The author commenced by saying that, al- though the question of lunar influence on the atmosphere of our planet was very generally considered as set at rest by the investigations of M. Arago, yet he felt very confident that he was in a position to prove the law he was now about to announce without fear of contra- diction. He had reduced and thrown intothe form of tables and of curves 280 lunations, with the corresponding mean temperatures; and the laws at which he had arrived were, first, between the first and second octant the temperature immediately after the first quarter, both on the average, and also, with rare exceptions, in each individual lunation is higher than the temperature shortly before the first quarter; secondly, and more partic- ularly, the mean temperature of the annual means of the second day after the first quarter (or the tenth day of the moon's age) is always higher than that of the third day before the first quarter (or the fifth day of the lunation). The tables and curves accompa- nied the essay, which illustrated these laws at great length. " (Rl, R2) R1 is a summary of R2, which is more difficult to comprehend, if that is possible!

X2. Statistical analysis. North Wales, 1947-1951. Daily records of mimimum temperatures have been kept during many years by observatories and meteorológica! stations, but such records have appeared in the form of long columns of numbers, among which an abnormality might remain unnoticed, unless special search were made for it. In a previous publication from similar lists of mínimum night temperatures taken in North Wales, monthly graphs were drawn, with temperatures as ordinates and days of the month as abscissae, for each of the years 1947, 1948, and 1949. When temperature curves were drawn, there appeared a regular fall in the mínimum night temperature at or near the date of full moon at each lunation during the three years.... The temperature fall was sometimes gradual, its incidence being as much as a week before and its lowest point occurring on the date of full moon, or generally within 48 hr of it. Mostly, however, the curve of the fall was more sudden, being limited to 2 or 3 days. " The author also acquired temperature records from other stations around the globe, which confirmed the lunar effect detected in the data from Wales. (R3) In a second paper, the author noted that the fall of mínimum temperature near the full moon was less in the summer than in winter; a phenomenon paralleling oceanic low tides. He then pos- tulated that the temperature effect, too, was tidally induced and due, perhaps, to the adi- abatic expansión of the atmosphere under lunar influence. (R4)

X3. Statistical analysis. Syracuse, New York. Data from 1931-1946. "The results were striking. During the summer period there is a gradual increase in temperature from just prior to the new moon until a week after the full moon, followed by a rapid fall of 4° within the next week. The lowest point is reached two days prior to the new moon. The sltuation during the winter period isnot quite as clear-cut. From just prior to the n6W moon until the first Quarter, an írregu** lar but marked rise in temperature takes

place, over a range of approximately 4°. Between the first quarter and the full moon, a slump occurs, with a fairly distinctive hlgh ending it immedialely following the full moon. This slump is a crude inverse ofthe rise durlng the same interval of the summer period. Another marked slump follows, between the full moon high and the new moon, reaching its lowest point two days prior to the new moon. The slump is essentially the inverse of the rise that occurs during the summer period following the full moon." (R5)

X4. Statistical analysis. Yakima, Washington, 1949-1952. Daily mínimum tempera- tures for 45 lunations. "In each case, coun- ting in the occasions when two equal falls occurred, one at full moon and one at some other time, the greatest fall carne at full moon on only 20 occasions out of 45. Although this is more than would be expected, since the 6-day period around full moon is only about one fifth of the total time, it is far from being the rule. Of the 14 occasions of greatest fall at full moon during the past 3 1/2 years, 3 carne in 1949 , 8 in 1950, 3 in 1951, and none so far in 1952. Thus the distribution is erratic. " (R5)

X5. Statistical analysis. Riverside, California; data from 1942-1951. The analysis shbwed no significant different in mínimum temperalure fall between the full- moon interval and any other interval. (R5) X6. Statistical analysis. Ottawa, Regina, and Edmonton, Cañada. Mínimum tempera- ture data from 1950 and 1951 . "On the basis of the data analyzed here there is no indication of any tendency for the greatest consecutive fall of mínimum temper- atures within 48 hr of the full moon to be significantly greater than falls for any other phase of the moon. " (R5)

X7. Statistical analyses. Several Canadian weather stations; data from 1947. This study suggested that the fall of tempera- ture near a full moon is greater than at other times but not overwhelmingly so.

(R5)

X8. Statistical analysis. Boston, Massachu- setts. Temperature records for 78 years.
No significant relationship between mínimum temperatures and lunar phase found. But the critiques of other attempts to establish this phenomenon are more pertinent than the Boston resulta. "Unfortunately the data and me- thods employed by Henstock (X2) appear to invalídate hls findlng6 from the start. The acceptance of his results even as a working hypothesis for further research is not war- ranted. His data, at most 5 years at one station and single years at others, are absolutely insufficient in any attempt to evalúate such effects as lunar influences. It should be pointed out that, for example, the establishment of the magnitude of the lunar tide in the atmospheric pressure-------which can be shown to exist theoretically-------necessitated the use of about 350,000 observations even in tropical latitudes, where the other random effects upon the pressure are small! When dealing with mínimum temperatures we must contend with large random effects introduced by air mass changes, variations of insolation, and other factors, which re- sult in a large standard deviation of such temperature valúes." The author goes on to note that the lunar period is almost the same as that of solar rotation as well as one of the possible, stable, free oscillations of the atmosphere. (R5) The above criticisms should be applied to all GWS phenomena, including some of the analyses presented above that show jio lunar effects on mínimum temperatures.

X9. Statistical analyses: 1995-1997.
Abroad at night, one feels no warmth from the full moon. Well, one shouldn't, except perhaps for psychological effects. However, satellite instruments tell us that Arctic and Antarctic temperatures in the lower troposhpere (lowest 6 kilo- meters) definitely average about 0.55°C higher at full moon compared to the new moon temperatures. Not much, it would seem; but this full-moon polar warming is 25 times that of the global average! More than enough to perplex meteoro- logists. Even more puzzling is that contrary dip in mid-latitude minima first seen in the "oíd" series.

The major scientific puzzles are:

(1) Why is there any effect at all given that moonlight is merely greatly weakened, reflected sunlight?

(2) Why is there a "latitude effect" in which the polar regions are warmed while the mid-latitudes are cooled, and the tropics affected not at all? Obviously, the effect is not due to direct lunar radiation, which is least at the poleB and highest in the tropics.

In contrast to the "oíd" measurments (X1-X8), which were mostly from single observing stations, the "new" data come mainly from satellite observations. They cover much of the globe. From these spacecraft data, we sce that the lunar

temperature effect ia global in nature. Explanatlons of these unexpected temperature correlations with lunar phase (positive and negative) inelude satellite-instrument artefaets, the lunar tide in the atmosphere, and the earth being closer to the sun at full moon (4,700 kilometers closer than its average diBtance). (R6-R11)

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GWS8 The Purported Effects of the Planets on the Weather

Description. The statistical correlation of any of the various terrestrial weather phenomena, such as mean temperatures and rainfall, with the planets, particularly the positions of the major planets.

Background. While scientists can now hypothesize some physical mechanisms by which the sun can directly affect the earth's weather, the slowly wandering planets have no known physical ties of significant magnitude with the earth. In addition, planetary influences are redolent of astrology-----science's ancient enemy. Astrological trappings are to be avoided at all costs. Still, solar activity has been correlated with planetary position in respectable journals (ASO). Planetary position, therefore, may correlate with terrestrial weather as a secondary effect. Of course, the means by which the planets modulate solar activity, if they do, is unknown, for gravitational tides seem far too weak.

Data Evaluation. Few scientists have dared to investígate this possible anomaly; so thedata are sparse and of poor quality. Rating: 3.

Anomaly Evaluation. Modulation of the earth's weather by the planets, even if indirectly accomplished via solar activity, would be an anomaly of the first rank, because none of the recognized forces involved; viz., gravity; is strong enough. Rating: 1.

Possible Explanations. Terrestrial weather modification by the planets could be an indirect result of their effect on solar activity; but this is just an appeal to another anomaly.

Similar and Related Phenomena. The correlation of solar activity (sunspot number) with planetary positions (AS09 in The Sun and Solar System Debris), terrestrial radio propagation affected by planetary positions (GER11 in Rare Halos, Miraees. etc,; all of astrology a subject not included in this catalog"----~—^{6}—'

Exampies uf the Purported Effects of the Planets upon the Weather

XI. Unsystematic observations, A curious Lheory with strong astrological overtones.
The author believes that the positions ofthe planets affect terrestriaJ temperature» and provides numerous exaniples from various localities to substanliatt his claim. Of more valué here is his ovvn statement of philosophy. ”You wiíl thus see, Mr. Editor, that by the aid of the planetary philosophy i have enunciated that I arn not only able tu show a remarkable similarity of phenotnena, but to Lrace each occurrence up through the several years, sulving the dtfficulty uftheir occurrence at times varying with the motion of the planets ín the ¿ixiiac. and thus demon- strating them to be eaused by planetary at- traction, and not by solar influenee, the same phenomena marking ten other positions, Ln which the planets are totally independent of solar combination. (Rl. R2, R5) We do not record the author's supposed cxamples of success because, with the world’s varied weather at any given mornent, one can always find a temperaturc change that will "preve" the influeneeyof any planct. (WRC)

X2. Unsystematic observations. "To the maxiy popular and scientific opinions as to the cause/ of rain 1 would beg to add one that 1 ba\e not yet seen described in any book— vi/.., the Lníluence of the moon when passmg Venus, Júpiter, and other planets. It may only be a peculiarity of this ’stationj but J have noticed over and over again that rain falls when the moon at night Is two or three degrees to the west of Venus or Júpiter, when these planets are in the west, or when the moon ín the morning is two or three degrees to the east of a planet situated in the east." (R3)

X3. General observation and speculations about the possible influence of the planets on the sun and consequent solar effects on ter- restrial weather. "While it is true that a conjunction of the great planets produces no marked disturbante. it is belíeved by high authority that sun events have slight influ- ence «»n tho Sun through media and Ln ways, not yet understood. WTien either Júpiter, Venus or Mercury passes nearest the Sunin the ir respective orbits, the solar sur face seems to show greater activity than usual, Ihnugh no marked changos have been observed, ñor could they be naturally expected from such a cause, Un tho other hand, it is well established that intense solar activity produces magnetlc storms in the carth's atmo- sphere, some of which have been singularly puwerfui in recent years. Whatever irdiu- ence the perihelion passage of certaín planets may have in agitating the solar surface, it is plaín that the earth must share in the results. Lf the-íe be very small, or too deli- cale to meusure by knowm methuds, it should not Le turgor ten that they may bt constant and extend over considerable period uf time, and that conjunctions, or near groupings, of the major planets are favorable times for the exercise of these unknown eos mi cío roes, whatever they may be in kind or extent... . Recent interesting coincidences invite astron- omers to this study. The year 1883, very probablv marks the máximum of a passing sun-spot period. ln some locations, cer- tainly, last year will be long remembered for its cyclones and tornadoes. ln a group of nine Western States, the Signal Service reports the occurrence of over fortv of these dreadful storms within the space of ícur months." (R4)

X4. Statistical analysis. "The ninetcenth century discarded horoscopy of the weather with the other appurtenances uf astrologv.
Dr. 7,. Kamorling would have us reverse this verdict and employ the motions of the planets as the basís of long-range forecae- ting. His thesis is that widespread perio- dicities must ha\e a cosmic ongin, and sun- spots having failed, there remam only the planets. Accordingly he investígales peri- odicities of the length oí the ’synodic rota- tions,’ that is, the intervals between the dates at which the various planets are nearest to the earth. (It appears that the theo- retícal basis of this planetary connexionhas been given in a previous paper; one wonders what it can possibly be.) i hese giv, him in years: Venus 1.60, Mar» 2. 13, Jupití r 1. 09, Saturn 1.035, Uranus 1.018. material he has forty \ears oí average monthly rain- fall over east Java and over west Java, twen- ty years' rainfall at Pernambuco, and tem- peratures at Winnipeg, Konigsberg, and Zwanenburg The nielhod is to wríte- down the monthly data in sets corresponding with the ’synodic year,' so that, fot example, all the months of perigee come in the same vertical column, and !<> plot the smouthed means of these columns From hisgraphs, Dr. Kamerling concludes that theie are real periodicities corresponding with the synodic periods oí eaeh piarte!, giving maxiina gene- rally near perigee and secondary maxima near apogee.

Such a rei-ult would be of considerable importance it substantiated, as explaining the origín of a numbt i of periodicities of a

iitlle more than a year which have been suggested frnm time to time, but unforíunately Lhe author has nut done aLI he might to prove his case. He does not exprese his periodie- ities as Fourier series, ñor does he attempt Lo determine their exact length, The original data are given only for the east Java rain- fall, and here inspection shows that the an- nual variation has not been complete!)' elimi- nated. They show, in fact, a residual mean annual variation with a range of 16 mm. , which is of the same order as the ranges of the planetary periods. The normal used ap- parently covers the first thirty-three years, so that the error is entirely concentraíed in the last ¡>even)e,ir?, and falsifies any apparenl pcríods upto 1.1 year. The supposed period for Uranus (1 year 4 riays), with a range of 18 mm. is almost entirely due to this residual annual variation. The author does not give the standard deviaWms of the data which he uses, so that no test of realíty can be made. The Venus period in east Java, which has by far tht largest range of any, may be taken as a test case. The amplitude ofthe correspondiug Fourier series isfound to be 9 mm. , and the standard deviation of the i.riginal 480 valúes is 63 mm. The amp- Ütude is therefore 4.5 times the expectancy on a chance basis, and the period s«:ems to be real. Its exact length, however, turns out to be 1. 55 year, while the 'synodievear' of Venus is 1.60)ear; this means that the máximum pha.se shifts by about 120° in forty calendar years, which seeins too great. and the intí rpretation suggested is that there is a periodicity in the east Java rainíall which happens nearly, but not quite, to coincide with the Venus synodie year." (R6)

X5. Statistical analysis. "If sunspots influ- ence the curse of the weather on the eartb (and presumably also on other planets) the planets in their turn influenee the formation of sunspots, and thus indirectly their own weathe»- events. A statistical study of cor- relations between the positions of the three planets nearest the sun-----Mercury, Venus, and earth—and the numbers and positions of sunspots has been made by Dr. Fernando Sanford of Palo Alto. Dr. Sanford has re- ported his results through the Smithsonían Lnstitution, whcse secretary, Dr. Charles O. Abbot, has been a leading investigator inte» the question of a possible connection between sunspots and wealher " (R7)

X6. Statistical analysis. "A 1980 paper, 1 he Effeet of Planet Mnvement on Changes ín Climate, [1] by Ren Zhenciiu of the Peking Meteorological Instituto and Llu Zhilin of the astronomy departmeut of the Chínese Science Institute, has just arrived ín the U. S. Through charts and graphs, it tracks 19 past planetary alignments and finds (accor- ding to a translation privately commissíoned by this newspaper) that 'for the past 3, 000 years, China's temperatures have cbanged in accordance with the seasons of the planetary alignments. '

Most alignments carne at intervals of 178.7 years, some more frequently. The most recent was Jan. 24, 1844. Eight align- menls carne in the summer half of the year, and 'aU of those eight periods were relative- ly warm ones,[1] the paper says. Nine alignments carne in the winter half vvith the planeta cióse enougb to be inside an are of ˚?Q degrees ^as they will be this year), and in each case temperatures were below normal except for une in 631 A. D. , when weather data in China was unavailable. Two other alignments carne in winter, but vvith wide ares of ?s4 and 100 degrees; temperatures were mixed but on the warm side. Two previous alignments, in 1415 B. C. and 1595 B. C, were in summer and aceompanied by warm periods.

Messrs. Ren and Liu found that the narrower the are (the closer the planets), the more extreme the temperatures. 'During 1665, when the angle of eonvergence was smallest only 43 degrees- this corres ponded to-.. when China and the Northern Hemisphere nad the coldest temperatures of the past 3,000 years,' they said. They calculated that during alignmeuts The radius oí the earth's orbit around the mass eeuler of the solar system[1] is 1% longer than normal, extending une or another season accur- dmg to formulas they provide, They also studied Greenland's weather during the past five alignments, and found it 'consislent with the trend. (RS) These planetary alignments gained recent íame under the guise of the Júpiter Effeet. Another summary of the Chínese sLudy by John Gribbin, one of the authors oí the book The Júpiter Effeet, is found ¡n R9.

X7. Critique of the Chínese hypothesis described in X6. W. Roder, a geology professor ai the llniversity of Cincinnati, agrees that the planetary alignments seleeted by Zhenqiu and Zhisen do in- deed agree with Chínese historical data. They do not, however. fit well with the climatie curve derived from studies of the Greenland ice cores. The fit is even poorer for Iceland records. He asserts:

"Clearly, thess ínferred records oí past climates do not agree sufficiently with each othcr to pin a coid period on any short-term astronómica] event." In this manner, Roder rejects thc Chínese hypothesis and regrets that it was turned ínto "quasi-astrological hypc-." (RIO)

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GWS9 Comets and the Weather

Descnption. The dependence of terrestrial weather on the passage of comets through the iiuier solar system, particularly those that pass cióse lo the earth's orbit.

Background. Comets have long inspired fear in humanity and been regarded as harbingers of change----usually change for the worse. Not surprisingly, the onset of bad weather was frequently blamed on comets in our unscientifíc past.

Data Evaluatíon. No data even remotely approaching satisfactory quality exist. Only one scientist (Arago) is known to have dared to touch this subiect. Rating 4.

Anomaiy Evaluation. Comets being much less massive than the planets should exert even less influence on the. earth, either directly or through their effeets on solar activity. One would thus be tempted to classify comet-induced weather as even more anomalous than planetary modulatio» (GW'S8). This might be ineorrect because the passage oí comets could affect the earth's weather in a straightforward cause-and-effect manner, as described be- knv. Rating: 2.

Possibie Explanations. The passage of a comet may leave a huge wake of dust and gases, which if encountered by the earth might result in the influx of precipitaron nuclei. These in turn might lead tr. cíoudiness, precípitation, and lower temperatures.

Similar and Related Phenomena. Meteors correlated with weather (GWS4), auroras cor- related with meteors (GLA11).

Examples of the Purported Effeets of Goméis on the Weather

XI. Revlew paper. Mankind's curious pre- occupation with the baleful iufluence¿. of comets is discussed.as wcil us some coniet- weather folklore. Only in a very few insí anees have scientists deigned to examíne this subject. "Yet, though «he wide-spread and long cnntlnued beliet in the influenccb of comets upon the weather has even survi vid the bellef ín their direct baleful influence upon the fortunes of humanity, we mu6t, neverthele¿s, place it in the same category as the supposed lunar Influence. In the words of the late Professor Young, we may say that ’there is no observable

change of temperature or oí any meteoro-lógica] condition, ñor any effect apon vege-table or animal Ufe produced by a comet, even of the largest size.' Arago, more than half a century ago, made some al- tempts todeal statistically with thequestion. He took the mean temperature at París for the years 1735 to 1853, placing side by side the number of comtts observed in eaeh year, and thus showed that years fruitful Ln comets, such as 180b and 1846, were mar- ked by temperatures lower or hardly equal to those of years Ln whlch few or no comets were seen. Sixty-níne years with comets gave a mean annuai temperature of 51.46 F, twenty-seven years in whicfa no coméis were seen gave a mean of 50.94, He considered this slight difference as explained by the fact that years without comets were inost frequently more cloudy than the others, the prevalence of clouds concea] ing comets from observation." (RI)

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GWS10 The Eclipse Wind

Dcscription. During solar eclipses, slight gusts of wind preceding and following totality. A train of weak pressure waves has also be observed to follow the rnoon's shadow.

Data Evaluation. The eclipse wind observations are for from robust Many re-ports, pro nnd con, havt appeared in the scienee literature, ln sum, some weak positivo evidence for the phenomenon exists. Only one observation of the trailing train of pressure waves ts in our files. Rating- 3.

Anomaly Evaluation. Wind disturbances during total solar eclipses can be explained by cyclonic disturbances attributable to the sudden loss of solar heatíng. The significant anomaly here is the unexplained train of pressure waves that are *re-porteó* to follow the raoon's shadow, Rating: 3.

Similar and Related Phenomena. Wind perturbations accompanying sunrise and sunset, as in the "cry of Memnon" at Egyptian desert sunrises (GSM-006 in our Sourcebook Strange Phenomena, vol. G2).

]• n tries

XI. General observations. During the solar eclipses of the 1800s, many obser-vers reported small changes of wind velo-city and direction during the passage of the moon's shadow. V/as there such a phenomenon as an "eclipse wind"?

A.L. Rutch, of the Blue Hill Meteoro-logical Observatory r.ear Boston, rumina-ted as follows:

"Theoretically, the passage of the moon's shadow, by suddenly chilling the atmosphere, ought to increase the baro-metric pressure along its path and so cause an outflow of alr in all directions. lnvestigations to determine the amount of this change of pressure were made by Professor Upton and the writer during the eclipses previously mentioned with the result that the changes which rould be attributed to the eclipses were found to be too small to measure directlv."
(RI)

X2. June 18, 1918. United States. The eclipse on this date was eited by J Anderson, in 1999, as the eclipse that convinced many astronomers that the eclipse wind was a mere "urban legeud."

"One source of the eclipse-wind legend may resull from studies done at the turn of the century by meteorologista with the US Weather Bureau. Kim- ball and Fergusson (1919) present a tíissection of wind changos during the eclipse of 8 June 1918 across the USA. They describe n weak component blowing toward the shadow axis from stations as mvu-h as 100» km from the path. Their

Rvidence is weak and subject to considerable subjective interpretation, appearing in some eclipses and missing in others" **ÍH2)**

From R2, st is obvious that, in 1999, just abouí all scientists were convinced that eclipse observers in or near the path of totality were over-reactmg---------- perhaps subjectively- -- to minor vícis- situdes of local winds that were in the main unconnected te the major astronon- ical event then under wuy.

X3. August 11, 1999. Despite the prevalen! negatism of 1999 [X2], a solar eclipse occurring that very year seened to rescue the eclipse wind from the urban-myth di ad-file and also add a new twist to the phenomenon.

Physicist K. Alpin and meteorologist G. Harrison were not contení with the trashing of the eclipse wind. They re- called that the American meteorologist A. Clayton hnd shown back in 1901 how the moon's shadow should be trailed by a cold-core cyclone that would easily ex- plain the eudden, slight wind gusts that many observers in the paths of totality experienced just before and just after totality.

Alpin and Harrison. probably in the face of mueh ridículo, set up instrumen- tation for the August 1 1 , 1999, eclipse in the UK, at Tieading, where the eclipse was partial, and in (ornwall, where 5t was tutal.

"They now {2002] rep>ort that at both sites, there was a slight gust at the beginning of totality and another at the end in the opposite direction, just as Clayton had suggested in 1901. At Reading, they also picked up small changes in atmospheric pressure. Tbese peaked every 35 minutes and peristed for hours after the eclipse. Such pres- sure waves are probably set up by the coid eclipse shadow racing across tlie sky at supersonie speeds." (R3)

In conclusión, weok gusts of eclípse wind are not mythicnl, and there are also a following, unexplained, pattern of smídl pressure waves.

References

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R3, Muir, Hazel; "Moon's Shadow Stirs Up Eclipse Wind," New Scientist, p. 17, November 30, 2002. (X3)

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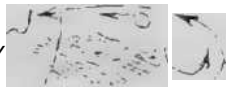

Jn íheory, a cold-core cyclone follows the moon's shadow across (he landscope. Ground-leve! wind ¡/usís should occur as shown (R3 >

GWT THE IDIOSYNCRACIES OF TORNADOS AND WATERSPOUTS

Key to Phenomena

GWTO	**Introduction**
GWT1	**The Tornado as an Eléctrica! Machine**
GWT2	**Burning and Dehydration during Tornados**
GWT3	**Tornados and Waterspouts with Horizontal**
GWT4	**Funnels**
GWT5	**Muitiwalled Waterspouts**
GWT6	**Anomalous Histórica! Incidence of Tornados**
GWT7	**Reversal of Rotation in Waterspouts**
GWT8	**Pranks of the Tornado**
Gwnrg	**Tornado Incidence Correlated with Magnetic**
GWT1	**Variation**
0	**Landspouts or Dustspouts**
GWT1	**Waterspouts between Clouds**
1	**Forked Waterspouts**
GWT	**Abnormally Thin Waterspouts**
12	**Waterspout Funnel-Knots**
GWT1	**Bull's-Eye Squalls or White Squalls**
3	**Tornado Onset Correlated with Intracloud**
GWT1	**Lightning**
4	**Anomalous Fallout of Debris from Tornados**

GWTO Introduction

Üstensibly. tornados and waterspouts are the sanie speeic-s of rotary storm. The pas&age of a tornado f! om land to water convertí it automaticaJh inte a waterspout, or So the pre- vailing theory gots.

A controversia! theory that uniles the two phenomena is that of their purported eléctrica] origin. Both tornados and waterspouts areusually acccmpanied by severe lightning, but the hypothesis oí eioi trica! origin requites powerful cloud-earth currents to keep the storni's motor running. The effects of this large-scaJe flow of electricity should be observable. The "tornado lights" catalogad under GLD10 may be considered evidence of eléctrica! action of some kind. i >ther confirmatory phenomena are: large terrestrial current flow in the neigh- borhood of the funnel, the smell of ozone or sulphur, and burning and dehydrating effects noticed alung the path of the tornado. The latter effects, however, are also attributed to the aerodynamic heat creaíed by the tornado. Whatevor the truth may be, the au.xiliary phenomena accompanying tornados are niost curious.

The theory of the waterspout is not as completely worked out as sume rueteorologists would like. They find that the hollow-lube geometry of the waterspout is different from what some theories imply. Along this vein, conventional wisdom also has trouble dealing with forked waterspouts, waterspouts between clouds, and muitiwalled waterspouts.

Both tornados and waterspouts can be dangemus phenomena; the former generaily beíng the

more víolent. One must also ask whether there is a continuous gradation in size and violence from the smal! raischievous dust devil to the town-levelling tornado a milc wide. Do all oí these rotaiy phenomena have the same cause? Meteorologista, in fact, do no(understand completely the génesis oí atmospheríc vórtices. Somethlng seems to trigger these atmo- spheric mac-lstroms; perhaps electricity or natural surface íeatures or oven automobile traf- fic!

GWT1 The Tornado as an Electrieal Machine

Description. Eléctrica] attributes of tornados above and beyond the intense lightning normally expected during a severe storm. Collectively, these phenomena imply that u>rnados may owe their origins and maintenance to electricity. Pertinent phenomena are: (1) Tornado lights, which are dealt vvith at leDgtb in GLD10; (2) Anomaious heat generation and the dehydration of vegetation, as described in GWT2; (3) The smell of ozone or sulfur; (4) Buzzing or other sounds typical of electrieal discharges; (5) Radio noise (sferics); (6) Strong earth cúrrente in the neighborhood of tornado funnels; and (7) The apparent impossibility of generating tornado Forcé wtnds by means of any conceivable temperature differences attainable in the atmosphere.

Background. Today's meteorologista doubt thaL electricity plays any significant role in tornado génesis and maintenance. A cenlury ago. however, the major importance of electrieal forces was widely accepted.

Data Evaluation. Tornados are attended by many electrieal phenomena; this fact is widely acknowledged. It is a question of whether electricity is essential to the birth and maintenance of the tornado. If electricity is important, electrieal phenomena in and around all tornarlos shcuId be strong. This does not seem to be the case. Rating: 2.

Anomaly Evaluation. The current scientific consensus denies a major role to electricity in generating and sustaining tornados. Rating; 2.

Possible Explanations. Power ful electrieal discharges between clouds and the earth (not lightning but somethlng more akin to a glow discharge) may contribute to the formation and maintenance of tornados. The mechanism by which electrieal energy is converted into vortex energy is not well-understood.

Similar and Related Phenomena. Electrieal propertios of whirlwínds (GVVVV4). tornado lights (GLD10); earthquake lights (GLD8). The latter two references are in Remarkable Lurninous Phenomena.

Examples of the Tornado as an Eléctrica! Machine

XO. Cross referente. Lurninous phenomena, probably of electrieal origln, have been observed around many tornados. These anomalíes have been collccted under the category GLD10 in another volume of this Catalog.

Xl June 3, 1860. American Midwest. A tornado leaves a strong sulphurous odor in many places. (R2, R3i

X2. April 10. 1885. North Atlantic Ocean. When a ship encountered a waterspout, much St. Elrno's Pire was observed around the ship. (R4)

X3. May 27, 1062. Tulsa, Oklahorna. Earth current measurements near a large tornado.

Abstract. "Measurements of the magnetic field and earth current in the vicinity of a tornado show large step-like deflections co- incident with the touching down of the funnel. Calculations with a simple current model indícale that a mínimum current of several hundred amperes must be postulated to ac- courit for the observed deflection in magnetic field. The exii tence of a steady current of 225 amperes fur a period of about JO minutes provides joule heat at the rate of approx- imately 10^ joules per second, and involves a total charge transfer of 135,000 coulombs. The calculations imply that a tornado iselec- trically equivalent to severa! hundred isolated thunderstorm cells active simultancous-

1> . " (R?)

X4. March 24, 1975. Atlanta, Georgia. Sferics associated with a tornado. Abstract. "Joint observations by radio and high-fre- quency sferics detectors at Georgia Instituto oí Technology provided unique data on the Atlanta tornado of 24 March 1975. The clas- sic hook echo was detected by radar at a range of about 26 km, 15 min before the tornado touched down. Wbile the tornado was on the ground the sferics burst rate was very low, despite very high valúes recorded immediately before and after thjs ínterval. Tbis observation, together with visual re- ports of a strong cloud-to-ground discharge at the time of tomado touchdown, suggests an Lnteraction of the tornado with the electric field of the storm. ” (R9)

X5. General observations. "Water-spouts often leave behínd a sulphureous (sic)smell, and there are examples of a disagreeable smell remaining along the whole tract tra- versed by them. One Individual, however, who became involved in a w'ater-spout per- ceived no odor. We seldom read accounts of water-spouts wíthout finding also that electrical phenomena were noticed at the same tíme. Ligbtning is almost never wan- ting: thunder is likewise often connected with them, and it has been remarked that the loud notse which follows water-spouts easily prevents feeble peáis of thunder from being heard. Now and then. a more widely dispersed light has been seen; so thatpeople imagined that the corn in the fielde was on fíre, but afterwards to their joyful astonish- ment found it uninjured. It has been reported of one water-spout that fire balls proceeded from it, one of which was accompanied by a report like that of a musket. " (Rl)

XG. Summary of field observations. Abstract. ’Eighteen cióse range tomado observations reveal that eléctrica! activity near or within the funnel is far too infrequent to lend cre- dence to eléctrica! theories of tornado gene- sis and maintenance." (R8)

X7. Laboratory experimenta made to check the possibility that electricity might play an jmportant role in a tornado’*, tifecycie indicated that a continuous electrical dis- charge in the center of a vigorous vor- tex actually inhibited vortex círculation. tR6)

X8. Theoretical arguments. The remarkable feature of the tornado is not its energy but rather its energy density. "Some idea of the extraordinary energy concentration in the tomado can be obtained by estimating the temperature differences that would bave to exist in the atmosphere to cause its winds.

We can compute an absoluto minímum tem- perature difference that would be required by consídering the atmosphere as a períect heat engine in which al! processes are reversible and in which dissipatíve processes such as turbulence, entrainment, and fric- tion do not occur.....From the foregoing considerations it can be seen that in order to cause the winds of near Sonic velocity that appear to exist in the tomado, temperature contraste must occur between air masses that are well in excess of the theoretical mínimum of 70[]C, and probably of the order of several bundred degrees centigrade. The puzziing fact is that none of the soundings made during conditions that cause tornadoes shows the possibility of such temperature contrasts. Even the most unstable atmo- spheric conditions.....are capable ofgiving rise to thermal contrasts of only 25°C between alr masses. This ts well below the theoretical mínimum that would be required to produce tomado velocitles..... The clue that may provide the answer to the riddleof the tornado is the very intense electrical display that is commonly observed to ac- company these storms. According to modero thinking, this unusual electrical activity does not play a significan! role In tornado dynamics. McEachron and Jones suggested that perhaps the tornado ítself somehow causes electrification. This appears unlike- ly, however, for both Jones and the Air Weather Service sferics observers at Tinker Field, Oklahoma, have shown that very intense electrical activity both precedes and follows the appearance of the funnel. Ii the tomado does produce tbe lightning that is observed to accompany it, then its energy is even more remarkable, for it will be shown that the power required for the light- ning display is commensurate with the power required to produce the tornado winds them- selves. It appears to the author that the ancient idea that electricity is a cause, rather than a result, of tornadoes inay afford a better explanation of the facts. The vivid electrical displays observed, particularly with nocturnal tornadoes, are so striking that the obvíous deduction that tornadoes might be caused by electricity is oíd indeed. ” (R5)

X5. Laboratory experiments. Abstract. 'Laboratory experiments showed that under certain conditions of vortícíty the electrical heating produced by a high-voltage discharge at atmospheric pressure can cause the íor- mation of a miniature tornado-líke vortex. Chice it forme, this vortex stablllves the electrical discharge along its axis and chan-

ges üs character from that oí a spark Lo a high-pressurc- variety of glow discharge. Eléctrica! and dynamic parameters worc measured. By relaiing observations aod measurements made ín these experiments to previous Work and to analogous situations in nature, it is coneluded that the heating produced by electrical discharges in a large storm may play a significan! role in forming and maintaining natural tornadoes." (RIO)

X1Ü. May 25, 1955. L'dall, Kansas.
R. Gunn. U.S. Weather Bureau, took electnc-field measurements nt eight. locations during this very active tornado. He reported: "There is little evidence suggesting that the electrical effects near the funnel differ basieally from ordinary thunderstorm electrifieation." **(Rll)**

Xll. January 10, 1994. Farnham, Surrey, United Kingdom. *Ai* 0448 GMT, following a sudden cessation of rainfall, n.D.
Smith beeame aware of nn orange glow outside his window. Accompanying ít was n roar like that of a military jet. The phenomenon occurred a total of fovir times; the second of which is the most interesting and now follows.

"A second illumination was observed twenty secónds later, but this time it reappeared a iva y from the tree so n clear view was possible. The illumination was in the furm of a narrow column and of the classic gentío 'S' tornado shape in the 'roping out' stage; it was sílver\ in colour towards the t<»p and golden- orange lower down. Addilionally» Mr. Sroith saw the illumination move from the sky towards the ground, but at a speed siower than lightning. i'he sound of rushing wind was heard again, while this illumination lasted five to six seconds." (K12)

'1 he slowly descending iuminous región is thought to have been an anomalous electrical-discharge phenomenon ,

Although ordinary lightning accom- panies many tornados, glowing columns suggestive of other types of electrical discharge are not part of prevailing tornado theory. Nevertheless, observa-tions of glowing discharges within the funrn ls of nighttime tornados—making them look like neón lights—have been observed and even'photographed. (GLD10 Iti Remnrkable Luminous Phenomena)

X12. January 21, 1992, Cripple Creek, Colorado. Shortly nfter 2 PM, while fishing 'it Skagwny Reservoir, D. Mc- Uov/n spotted an ominous cloud formation developing iii the west. A horizontal, blfti.k cloud i olled toward him. Suddenly, it hfted to reveal a huge, twisting fun- nel advancing directlv at him. He threw himself to the ground, but got a good look up into the interior of the funnel.

"The outside of the tornado *WEB* spin- ning so fast my eve couldn't follov. it, but the insicie was rotating alinost lazily.
I could see a thousand feet up insioe it. Tinv fingers of lightning lined the hol- low tube." (R13)

Passing over him, the funnel bounced across the lake, ripped up some trees, and was gone.

X13. August 28, 1990, Plainfield, Illinois, The electrical effects of this tornado— one of eight examples, listed by W.P Winn et al, is calleo a "striking exomple of electrical behavior associated with a tornado ." Winn described it thusly .

"Durlng the 20 min of tornado formu- tion and intensificntion of the Plainfield. Illinous, tornado of August 28, 1990, the cloud-lo-ground (CG) lightning activity was much reduced. Furthermure, the dominant CG flash polarity changed from positive to negativa over the entíre thunderstorm orea at the time nf the tornodo. (R14)

It is 6urmised that some of the flow of CG electricity was trnnsferred from the lightning to the tornado funnel. The polarity change, to<>. was i'emarkable.

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GWT2 Burning and Dehydration during Tornados

Description. The observation of the effeets of Intense heat along the track of a tomado, such as evidence of fusión, charred bodles, and vegetation that has been scorched, dehydrated and/or exploded. The smell *oí* sulphur, possibly indicative of eléctrica] action (GWT1) is aJso frequently present. Curlously, a disproportlnate number of examples come from France, where tornados are much less frequent than in the United States.

Data Evaluation. Although this pheomenon is sometimes described as if it vvere vvell-suppor- ted by observations (RIO), high quality examples are scarce in the literature. Rating: 2.

Anomaly Evaluation. Burning and dehydration along a tornado track suggests extremelyhot winds and/or intense electrical discharges. Neither are accepted characteristics of tornados. Rating: 2.

Possible Explanatíons. Powerful electrical currents generated by the tomado (GWT1). An oscillating ring current around the funnel (RIO). Aerodynamíe heating of the tomado coréis a possibllity, although the temperalures required for the observed effeets are probably seve- ral hundred degrees. However, if tornados can drive straws into trees (GWT7), aerody- namic heating may not be unreasonable.

Similar and Rcloted Phenomena. Tornado electrical characteristics (GWT3); tornado pranks (GWT7); whirl winds of firu and smoke (GLD11) tornado lights (GLD10).
The latter two rtferences are in Remarkable Luminous Phenomena.

Examples of the Drving and Burning Effeets of Tornados

XI. June 1839. Chatenay, France. An ae- count oí an especially vlolent tornado. "In this hasty account I ¿ave, with the intention of returning to this portion of the subject, omltted to speak particularly of its effect upon trees. All those which carne within in- fluence of the tomado, presented the same aspect; their sap was vaporized, and their igneous fibres had become dry as íf kept for forty-eight hours in a furnace heated to nlnety degrees above the boiling polut. Evi- dently there was a great mass of vapor in- stantaneously formed. which could only make its escape by burstlng the tree In every direction; and as wood has less cohesión tn a transverse directloD, these trees were

all, throughout one portiun of their trunk, cloven into laths. Many trees attest. by their condition, that they served as conductora to contínual discharge oí electricity, and that the high temperatura produced b\ this passagc of the electric fluid, ínstantly vaporized all the moisture which they eon- tained, and that this instantaneous vapon- zation burst all the trees open in the direc- tion of their length, until the wood, dried up and split, had become unable to resist the forcé of the wind which uccompanied the tornado* ln contempiating the rise and progresa of this phenomenon, we see the conversión of an ordinary thunder gust into a tornado; we behold two masses of clouds opposed toeach other, of which the upper one, in consequence of the repulsión of the similar electricities with which both are charged, repelling the lower tovvards the ground, the clouds of the other descending and communicating with the earth by clouds of dust and by the trees. This communication once formed, the thun- der imniediately ceases, and the dlscharges ol electricity take place by means *oí* the clouds, which have tnus descended, and the trees. " <R1. R3, RIO)

X2. August 19, 1345. Rouen, 1ranee. The famous tornado of Monville. "The trees Ln the vicinity were ílung dowm in everv direc- tion, riven and dried up for a length of frorn six to twenty feet and more. While clearing away the ruins, in the attexnpt to rescue the unfortunate people buried beneath them, it w'as noticed that the bricks were burninghot. Planks were found completely charred, and cotton burned and scorched, and many pieces of iron and Steel were magnetized. Some oí the corpses staowed traces of burning, and others had no visible cuts or eontusions, but seem to have been killed by iíghtning. Workmen who were hurled into the surroun- ding fields, all agreed in sayíng tbat they had scen vivid flashes and had noticed a strong smell of sulphur. Persons who hap- pened to be on the adjacent heíghts, alleged that they *saw* the faetones wrapped in flames and smoke as the cloud enveloped it. " iR2, R4)

X3. 1860. Iowa. A tornado left a sulphurous odor and blackened bodies of victims. (R5)

X4. Circa 1380. No **place** given. "The tornado was preceded by a dark cloud fromw'hich there was considerable thunder and líghtning, but the re was very lLttle, if any, near the tornado. After the storm had passed, the air was saturated with ozone to such a degree that even the binall cblldren noticed it, who compared it to the odor of burning brimstone or burning matches. Unfortunately. 1 once stood a few rods from a tree when it was struck by iightning, and I distinctly remera- bei the peculiar odor which I attríbuted lo ozone which had been formed by the passage of líghtning through the air. As the odor which followed or accompanied the tornado was similar, I eoneluded there must have been electricity with it. 1 followed the path of destruction, which was not orar ten rods wide, for a couple of miles, and at different places saw small hickory and white oaktrees, from one to two Lnches in diameter, ruptured or burst open, wáth crevices on all sides as though they had been exploded with some ex- plosive; the fine splinters standing out,brush- fashion, on ali sides. These small trees grew on ground which had once been farmed, and were of slow growlh and the toughest w'hícb grow. There was such a marked difference between these, and those which had been twisted by the wind, that I had no difflculty in distinguishlng one from the other. They were ruptured by electricity. At other places I sav small i oots which had been laíd bare, split open w ítriout any other tnarks about them, and 1 believe them to have been split by electricity. Had they been split by any visible or hard objeet, it must have left some other marks upon thetn. This, again, must bai e been the work of electricity. ” (R6)

X5. August lfi, .1890. Dotnagne, France. Ozone smell and scorched vegetation left behind by tornado. iR7)

X6. August 18, 1891. Dreux, France. After the passage of a tornado, traces of mel- ting were found in poorly conducting bodies. (R8)

X7. May 24, 1948. Mauritius. "In the mid- dle of the afternoon a whirlwind touched down to earth over a hard tennis court, cau- sing considerable damage to its hard com- pact sur face. A trench running in a north- south direction, 60 feet long and 1 to 2 1/2 feet wide, was cut in the bare surface of the court to a depth varying from 1 to 4 m- ches. The material lifted from the trench was all throwm to the west to a distance of 50 feet; pieces weighing about one pound were throwm as far as 30 feet. The surface material was slightly blackened as if by hc-ating, and a crack!mg like that of a sugar- cane fíre was heard for two ur thret- minutes. The court was made of a ferruginous clay, which paeks down to a surface more smoolh than that of the hard tennis eourts usually made in Great Britain. Unfortunate— ly, there were no very reliable witnesses

of th€ phenumenon, The impressions gained by two ¿ervants of the tennis club who saw the ¡ncident differed cunsiderably on importan t details. One elaims to have seen a ball of fire about tvvo íeet in díameter which erossed from a football pitch to the tennis couri through a wire-netting fence without leaving any evidence of its passage until it bounced along the court, making the trench in the surfaee befo re disappearing complete- ly. " (R9j This might very well be an ex- ample of ball lightning rather than tornado burning. (WRC)

X8. Theoretical explanation. Abstract. ᐟ'The explanation gene rally offered f«-r the observed dehydration, heating and burning effects associated with tornadoes js based on either of two mechamsms. The first in- volves a hol wind while the second involves corona diseharges sometimes called St.
Elmos fire, while Une smell of ’brimstone' often often appears to be overlooked. An altérnate explanation which could deal with both phenomena is obtained by assuming that a pulsed oscillatory ring current' ex- ists within the tornado cloud whose radiation fíeld at lurge distances can be associated with the observed and measured tornado sfer- ics and at trióle distances could be responsable for the observed heating effect along with tlie smell of burning ’sulfur. (RIO)

X9. June 1960. Kopperl, Texas. Thunder- clouds and lightning gave way to winds in excess of 75 roph, with temperaturas of up to 140°F. Surveying the storm damage later, townspeople found ampie evidence of the storin’s intense heat.

"Asido fron: the expected remains of a severo wind storm—uprooted trees. snapped telephone polos, roof damage and banged-up boats docked lakeside— the nrea had the ironic appearnnce oí having been stung by >« June freeze.
Tree leaves. shrubs, hanging plants and crops were eurled and wilted, as if frost- bitten. Uncut Johnson grass was dried and ready to bale, although the hay normally required two or three days of drying time after being cut. Perhaps the most startling remains of the storm was in what had been the cotton patch at Pele and Inez Burns’ farm. The cotton was about knee high and a ’lucious crop’ the dny before. according to the couple. The next morning all that was left were carbonized stalks peeping out of the ground. The corn fared little better." (Rll)

Xltí. August 16, 1985 Annesley Víood- house, United Kingdom. Here is an ex- ample of a so-called "scorching" tornado.

"V.'hat was interesting about the storm was not only the damage it caused, but nlso the type of damage After touching duwn the tornado uprooted a largo <>ak tree, 15 melres high. ín Lawn Road (luckily the residents of the house were away on a holiday). The tornado pro- ceeded to rip tiles off several roofs, denolished completely several green- huuses, and next scorched a 4-metre section of gable on the south side of **a** house in Forest Street (number 9). The gable section was srorched so badly that the gable had already been repainted when I called, although the evidence could still be seen." (Rll)

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GWT3 Tornados and Waterspouts with Horizontal Funnels

Description. Tomado and waterspout funnels that extend horizontally from the parent cloud for long dislances, often terminating in midair. Somt tornados display long sinuous funnels that deviate from the vertical huí not to the degree described below.

Data Evaluatiun. Horizontal funnel elouds, whilt rather raro, have been reliably reported and photographed. Rating: 1.

Anomaly Evaluation. Theory does not require that funnel elouds be vertical. In fací, one theory of waterspout forntalion has the funnel forming ¡nside the parent cloud in a horizontal pos i t ion and arching down toward the water only at its terminus. We must classify tbis phenoinenon as simply a curiosity. Rating; 3.

Possible Explanations. Funnel cloud orientation is determined more by meteorological forces than by gravity.

Similar and Related Phcnomcna. Horizontal roll elouds (GVVC12).

Examples of Horizontal Funnel Clouds

XI. May 24, 1909. Dtjon. France. A tornado with a horizontal, serpent-like fun- nei that terminated in mid-air. (RI)

X2. May 28, 1956. North Atlantic Ocean. "A most unusual waterspout was observed bearing due i., from the ship. It originated from a large Cb with rain falling, and stret- ched diagonally towards the horizon, as il- lustrated.....The waterspout lasted about 3 min before dissolving. ” (R2)

X3. June 29, 1976. Near Shawnee, Okla- homa. (R4)

X4, July 9, 1977. Waco, Texas. A horizontal funnel cloud was photographed near the top of a llDe of light thunderstorms. <R3)

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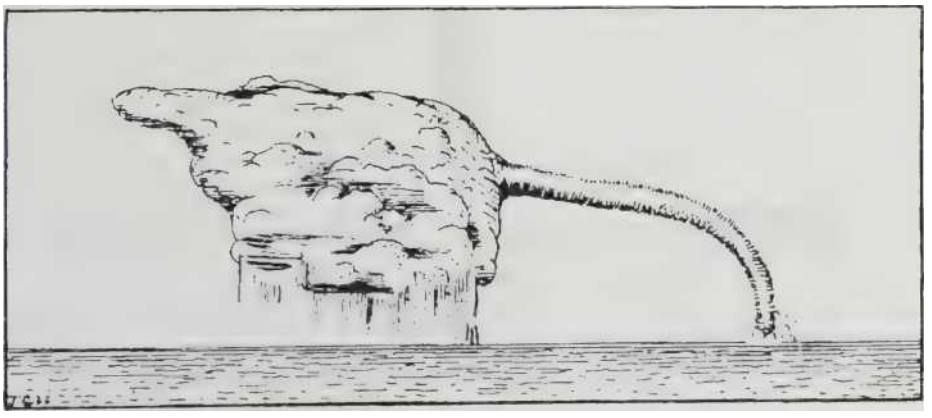


Waterspout with a long horizontal sectlon (X2)

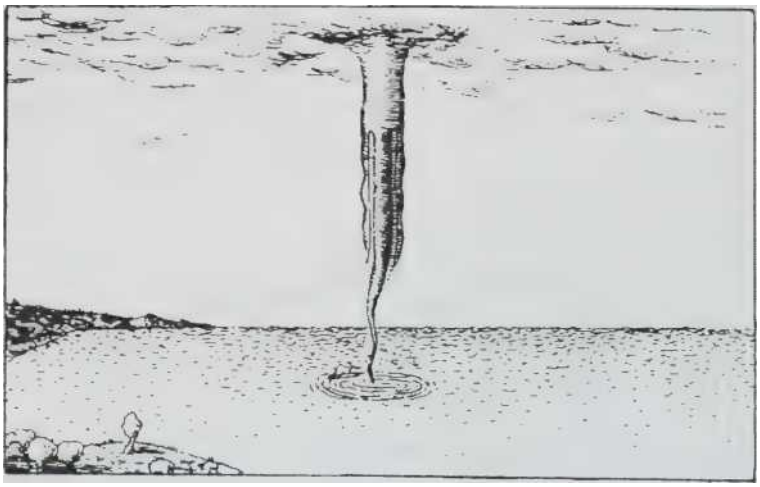
GWT4 Multiwalled Waterspouts

Description. Waterspouts consisting of two or more hollow eoneentrie tubes, which may rotate at different angular velocities. One tube is the rule but several double-walled and one triple-walled spout have been recorded.
Data Evaluation. Several detailed, seemingly reliable field observations of multiwalled waterspouts have been found. Furtber, the double-wall structure has been verified by láser probes. Rating; 1.
Anomaly Evaluation. Conventional waterspout theory deais fairly well with single-walled spouts but does not accomodate multiwalled spouts with eoneentrie walls rotating at various velocities. Rating: 2.
Possible Explanations. None.
Similar and Related Phenomena. None.

Examples of Multiwalled Waterspouts

XI. June 30, 1922. Lake Victoria, Uganda.
A waterspout passed 100 yards offshore. "The pedióle aróse from a well-marked circular area on the water, which was other- wise only faintly rippled b> the preliminary puff of wind before the approaching storm. This circular area was evidentíy very v»o- lently disturbed as a cloud uf vapour, greatly agitated, rose from ít for a little distance. The pedicle was extremely narrow at its lcwer end, and not quite straight, being sin- uous in outline. It breadened out gradually into a column which went up into the low cloud; the core of this column was much less dense than the periphery, and the vio- lent upvvard spiral ascent of the water could be clearly seen. So far i have described notbing unusual, but the following was quite new to me and seemed of great interest.

Surrounding the central core, but sepa- rated from it by a clear narrow space, was a sheath, the lower end of which faded away some distance above the water The profile of this sheath was undulating, it being thieker in some places than others. A curious point is that this sheath seemed to púlsate rhyth- mically, but 1 could not say whether the ap- pearance of pulsation might not have been an illusíon caused by wuves traveüing up its outer surface. This pulsation gave an uncan- ny suggestion oí a live thing, which was aided by the violent spiral movement upwards in the central core, the clouds of vapour boiling round its base, and the movement of the whole across the water ----------indeed, we watehed



Double-walled waterspout over Lake Victoria ÍX1)

it spellbound until lhe pedicle dissolved away at the bottom, and the ascent of the part abuve brought the phenomenon to an end. ” fRl, R2)

X2. February 22, 1923. North Atlantic Ocean. A report from the American steam- ship Warwick. "The spout was seen late ln the afternoon of February 22 and was describ- ed as ’close aboard' so that with glasses its peculiar structure could easily be observed. The inner spout was apparently darker than the outer and at times it would be withdrawn into the heavy globular appearing cloud above, leaving the outer spout sUll 'drawdng water. ’ The compound spout was something of the shape of an S, extending in a nearly horizontal direction to near the horlzon, where it descending vertically to the water. After about fifteen minutes the inner spout was suddenly wiLhdrawn and ten minutes later the w'hole mass moved eastward and a heavy rain set ln. " (R3)

X3. May 27, 1951. South China Sea. A three- walled waterspout. ’ It began as a faint tube of cloud particles etnerging from a cumulus bank estimated to be slightly above 2,000 ft. Directly underneath, the sea was disturbed and throwing up spray to about 100 ft. in a circular area 300 ft. wíde. In the second stage the tube, which appeared to be hollow. extended downwards to meet the surfaee spray. In its third stage, the tube wbich was about 30 ft. ıᴅ diameter, apparently formed a second hollow cloud tube inslde the first tube for about the middle third of its length.

In the íourtb stage, a thick cloud sleeve about 400 ft. long and 150 ft. wide grewdownwards from the cloud base, concealing the original spout and a similar sleeve or annulus grew from the sea ai the same time. The spray from the sea surfaee remained visible outsíde the sleeve. The reverse processes now took place, and when the spout had reached the second stage again a shower spread from the north, enveloped it and has- tened its decay. although it was possible to discern foam on the sea surfaee five minutes after the spout was no longer visible.

No rotation was visible at any time, except in lhe spray which appeared to drift slowly in a clockwise direction. " (R4)

XI. Láser probes of waterspouts off the Florida Keys, 1976. "With the láser devíce it was possible to measure wíndspeedir arvd identify tb»- dynamic difference------the dif- ference in velocity wíthin the spout that indican s twi> cylindt rs rotaling about a com- mon axis. Preliminary analysis of the data suggests that the two vórtices of a double spout are Ln fact two sepárate, concentric funnels which rotate in the same direction, but at different speeds. " tRñ)

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GWT5 Anomalous Historical Incidence of Tornados

Description. The appareot four-fold increase m the incidence of L?. S. lomados during the period 1950-1973 and, on a weekly time l'rame, a dramatic reduction in tomado incidence on Saturdays compared with the rest of the week.

Data Fvaluation. Little has been found lo date in the literature on this purported anomaly. The authors of the single study available admit possible problems with nonuniform reporting down the years but claim to have this factor under control Rating: 2.

Anontaly EvaJuation. No known natural forces account fur this strange distribution of tornados in time. Manmade sources oí atmospheric vorticity, as mentioned below, have not been accepted as >et. Rating: 2.

Possible Explanations. Automobile trafflc mav add vorticity to the atmosphere and account for both the general historical increase in tornados and the Saturday phenomenon.

Similar and Related Phenomena. None.

Exampies of Anomalous Historical Incidence of Tornados

XI. Statistieal analysis. "We have obtained tht detailed record of all US tomadoes (15,234) reported between 1950 and 1973 ín the 48 contiguous States. The annual ihci- dence shows an increasí over the period <4 a factor of four. Changos in observation and reportmg are undoubtedly serious and we have applied tests that are relatívely independent of secular changes in reporting.

.... .The data display a strong weekly peri- odicitv. Over the entire record the reported number of tomadoes on Saturdays is less than the daily average by more than 7.1 standard deviations (1,868 on Saturdays as against a daily average of 2,176). The statistieal probabílity of this record occur- ring bv chance from a random sample is PclO . This hebdornadal event dominates Ln 18 of the 24 yr and in most States. (Thir- ty-seven of the forty-eight States show a Saturday incidence below the average.) Nine teen States show Saturday's incidence to be a mínimum- ” (Rl) The ' Saturday Effeci" was suggested to be a consequence uf vag-

How motor vehicle trafüc crea tes atmospheric vorticity (X1)

aríes ín reporting by letters to Nature commenting on Rl. Severa] letter wrítcrs believed that auto traffic, which oeeurs on a small scale when compared to cloud di- dimensíons, could contribute no net vortici- ty to the atmospherp. (R2)

J.D. Isaacs added the following observation to his foregoing statistieai eorrelation of U.S. tornados and traffic.

"Another statistic that intrigues Dr. Isaacs and his eolJeagues is that a third of northern tornadoes spun clockwise before the rise of highway usage. Today, these wrong-vvay tornadoes ore rarr*. a phenomenon he believes mav be due to right-hand driving ín the area of tornado aetivity may be the reason for üie increase in more tornadoes." (R3)

References

Rl. Isaacs, John D. , et al; "Effeet of Vor- ticity Pollutioi) by Motor Vebicles on Tornadoes, ” Nature. 253:254, 1975, (XI) R2. Kessler, Edwin, etal; "Tornado Forum," Nature. 260:457, 1976. (XI)

R3. Anonymous; "Tornado Traffic," Science Digest, 77:28, May 1975. (XI)

GWT6 Reversal of Rotation in Waterspouts

E^escription. The apparent reversal of the direction of rotation ín some waterspouts.
Data Evaluation. A single observation. Rating: 3.
Anomaly Evaluation. The only known svay for a waterspout to reverse its direction of rotation and still obey the laws of physics is to slow down, die out, and reform on the same spot rotating in the opposite sense. This is unlikely and did noí occur in the example below. Lf waterspouts aetualiy do reverse rotation suddenly and spontaneously, theory cannot ac- count for it. Rating: 2.

Possible Explanations. The supposed change of direction is merely an óptica] ¡Ilusión.

Similar and Related Phenomena. The apparent direction of rotation of phos- phorescent wheels inay be either clockwise or anticlockwise. When múltiple wheels are present, both directions of rotation may be seen (GLW4 ín Remarkable Luminous Phenomena).

Examples of Reversal of Rotation in Waterspouts

XI. August 18, 1951. N'orth Pacific Ocean. "A waterspout ícrmed to the NE at a dislance of about one mile and moved westwards at 1U to 15 ht. It appeared to rotate rapidly. first clockwise, then anti-clockwise, contin- ually changing the direction of rotation. At no tune did it reach cloud leve]. Justbefore it dísappeared at 2039 u ceased rotating and dispersed temporarily. It finally disappear- ed veering WNW, leaving a cloud of spray." (Rl)

X2. September 28, 1991 . Western Mediter- raneari. Aboard the m.v. Staffordshire enroute to Port Said Of the severa] waterspouts observed by the crew, one exhibited anomalous rotation:

"At 0722 [UTC] the two spouta fur- thest forward and thp one on the beam dissipated leaving one which was of quíte a large diameler. about 20 in as eecn at o range of about 300 m. The direction of rotation of the water in tlie spout was clearly seen. Although tlie observers were aware that the direction

Of rotation shouíd be snticiock wise in this cape, they deciüed (with great sur- prise) that the direction of this particular one ivas clockwise. The only other spout that passed closer, within 15 m, ivas very weak, but the direction of rotation at the stirfaee was clearly «nli- clockwise." (R2)

We have no high quality records of tornados rotating in the "wrong" direc- tiun, except for the general comment of ,j.D. lsaacs in GWT5-X1, which we have not. been able to verify.

References

RI. Hutchinson, W.; "Waterspout,' Marine Observer, 22:123, 1352. (XI)

R2. Edwards, R.A.F.; "Waterspouts," Marine Observer. 62:113, 1992. (X2)

GWT7 Pranks of the Tornado

Pescription. The propensity of the tornado to carry out curious, improbable, and sometimos seemingly impossible actions; such as, defeathering chickens, driving boards through thick trees, and carrying people long distances without hurting them.

Background. Tornados, in common with lightning and whirhvinds, do the unlikely. At least these "pranks' and "freaks" seem improbable to us. The chief variety of tornado prank might be termed "surgical violence'' because incredibly strong forces are exerted over curi- ously delimitefj regions while adjacent areas are untouched. One should rememher in this context that tornados do not normally carry people 100 yards and set Lhem down unburt; they usually ki 11 and mangle people. Our statistics are thrown off because we tend to rernember the unusuaJ rather than the usual.

Data Evaluation. Tornado tales are legión. Only a sampling from the science-oriented lit- erature is recorded here. Tornado pranks are well-aeeepted phenomena. Rating: 1.

Anomaly Evaluation. Most of the peculiar actions of tornados could probably be explained if we could divine the detailed struelure of the tornado. That ís, if we knew wlnd velocitjes throughout the storm, present physical laws could give us a cause-and-effect accounting of each and every prank. Rating: 3.

Possible Explanations. Extremely high, localized winds probably account for almost ah of the so-ealled tornado pranks.

Similar and Related Phenomena. Falls (GWF); whirlwind pranks (GWW2); pranks of lightning (GLL1); "bizarre" ball lightning (GLB21). The latter two are catalogad in Reroarkable Lutninous Phenomena.

Examples of Tornado Pranks

XI. June 3, 1860. American Midwest. A tornado crossed lowa, Illinois, and Michigan, a total distance of 560 miles. "When the spout reached the lowa river, the spray was seen to come out oí its apex, making a picture. even more impressive than Niagra Falls. The evidences of the amazing power of the wind were innumerable. In one in- stance a joist was driven directly through a tree. At the time of the passing of the spout an odor of sulphur was noticed by many per- sons, and one of the most curious of the phenomena attending the storm was that many fowls were entirely stripped of their feathers, while the fowls themselves re- mained uninjured. " <R1)

X2. May 18, 1883. Sangamon Gounty, Illinois. A tornado attended by the odor of sulphur and fireballs. "The family of Mr. T, who had also sought shelter in a cellar from the same storm, were covered with a gummy

substance, which would not wash oíí! This substanee might have been formed from the sap oí trees and juice of leaves, combined with the moist heated atmosphere..... A thrifty young maple-tree, twelve Luches in diameter, stood apart from other trees, near the edge of the storm's track. About six feet from the ground the bark was peeled entirely off for a distaxice oí two feet. No broken limb, or uther missile, lay near the
tree, and its tup was uninjui-ed!.....A flock of geese were plucked of their feathers, which were deposited in a hedge-íence, giving it a complete coating. ” (R2)

X3. 1890. Louisville, Kentucky. A tornado toce the roof off a house and pulled a child from its mother's arms, depositing it safely at another house six blocks awav. (R5)

X4. May 11, 1892. Novska, Slavonia. Da- ring a powerful tornado, a young girlwas transported more than 90 meters without receiving any ínjury. (R3)

X5. May 27, 1896. Saint Louis, Missouri. ''Willis L. Moore, then chief of the VVeather Bureau, who visited St. Louis, Missouri, the day following the great tornado of May 27, 1896, reported seeing a two-by-four pine scantling which had been blown througb solid iron five-eighths of an inch thick on the Eads Bririge, the end of the scantling protruding several feet through the hole it had gouged in the iron. He also reported seeing a six by níne timbee driven four feet almost 6traight down ínto hard, compact soil, a gardner'e spade shot six inches intu the limb of a tree, and wheat straws forced into the trunk of a
tree to a depth of more than an inch.....a man driving a team to a heavily loaded wagón suddenl} íound the team missing, blowm away, but the wagón and himself uninjured, except, of cutirse, for the tongue of the wagón.” <R8)

X6. Circa 1905. Oklahoma. ”In the Associated Press dispatches concerníng the recent tornado in Oklahoma, mention Is made of the occurrence of some remarkable pbeno- mena which canoot be explained by our ac- cepted physical laws. Among these is a statement that ’all the corpses in the track of the storm were found without shoes.[1] ’In some instances the hair was taken from the head without injuring the scalp beneath. ' Similar storms have been reported with like curious phenomena, such as the remnval of the feathers from one-half a chicken, lea- ving the bird otherwise uninjured; driving a piece of straw several inches Into the trunk of a tree without breaking the straw, etc. ” (R4)

X?. March 18, 1925. The Tri-State tornado. ".....a large plank. several Feet long, was íound driven horizontally ínto a tree trunk so firmly that the far end of the plank was capable of supporting the weight of a man without loosening it from the tree. ” (R8)

X8. June 3, 1927. Topeka, Kansas. "....a rafter, badlj weathered and charred with oíd age, ivas blown from an oíd barn through the sidíng and two-inch sill of a nearby c.ompara- tively new house, pointed end first, and left sticking in the hole it punched. The most incredible part was that the eharred, tapered end of the oíd rafter showed no battering ef- fect whatever. The speed of its impact must have been tremendous.” (R8)

X9. March 14, 1933. Nashville, Termessee. The following were observed by the official in charge of the local weather station. "A cornstalk was found driven endwise through a piece of weather boarding. A 2 x 4 inch timber plunged through a panel door without causíng the slighest splittuig or splintering. The timber exactly fitted the opening. A 1 x 6 inch plank was forced through the trunk of a sturdy young tree, splitting the latterin half. " (R7)

Xlü. June 1. 1943. Lansing, Michigan. ”.....thirty chioktns, stripped entirely of their íeatíu-rs, .vet e lound aiter the storm sittíng in the poultry li<>use. stiffly at atten- tion. All were dead, " (R8)

Xll. June 23, 1914. West Virginia. "Ahen the destructive tornado of June 23, 1344, passecí ovor West lork River, West Virginia, the water was actually sucked up and the river left dry, momentarily, at the place where the storm crossed it. ” íR8)

X12. April 0, 1947. lliggins, Texas. ”Ac- eording to the account, two Texans, Al and Bill, last ñames noi gíven, were visiting in Al's home uear lliggins Texas, when the tornado that later struck Woodward passed over them. Al, hearmg the ruar, sti-pped to the docr and opened it it> see what was happening. It was toril from his grasp and disappeared. Me was carried awa> , ov>'r the tree tops. Bill went to the door te investígate the disappearance of his friendand found himself, also, sailing through theTex- as atmosphere, but in a slightly different direction from the eourse his friend was taking. Both landed about two hundred feet from the house with only minor injuries. Al started back and found Bill uncomfortably wrapped in vire. He unwound his friendand both headed for Al’s house, crawling because the wind was too strong to walk against They reached the site of the house only to find that

all the house except the flocr, had disap- peared. The almost ineredible part of the story is that Al's wife and two chiídren were huddled on a divan, unínjured. The only other piece of furniture lett on the flnor was a lamp. " (R8)

X13. Aprii 29, 1947. Wortb, Missouri. "«Mr. Ferguson arrived on the scene of devastation shortly after the lomado struck and observed not only dead, deplumed fowls, but alsoothers deplumed and dazed which expired in a short period of lime." (RIO)

X14. May 30, 1951. Scottsbluff, Nebraska. "«After the passage of a tornado at Scottsbluff, Nebraska, on May 30, 1961, a bean was found embedded one inch deep in aD egg without having cracked the shell." (R8) One assumes that a hole was made without cracking around its edges, as in X9. (WRC)

X15. June 8, 1953. Flinl, Michigan. ”Also, in our files, is a rather aged and yellow supplement to the Flint (MI) Journal showing a picture of a deplumed rhicken, ’pecklng around a truck twísted like a Steel pretzel' in the aftermath of the famous Flint Tornado of 8 June 1953. \Vh¡le it is not the mission of the National Severe Storms Forecast Center (NSSFC) to record t<rna- doos which deplumed fowls, enough events of this phenomenon hav$_{e}$ been documented o ver the past on*- hundred and forty years to warrant its acceptance. " (RIO)

X16. No date or place’given. "No account of tornadoes is complete without the recital of sume of the many 'freaks' which such storms are wont to perform. The removal of feathers from chickens, the complete destruction of houses, the clean sweeping through deep forests, and the carrying of objects great distauces, are examples fre-
quently recounted.....Here are some ex-cerpts from the numerous accounts.... An automobile locked in a garage was unda- maged, although the garage was blown to splinters. Half a dozen glass j.ars of fruit were carried 100 yards by the wlnds and not damaged." (R6>

X17. No date given. Texas. From a study oí survivors Ln a small Texas town that was struck by two tornados a year apart. "But the tornadoes did leave their mark. After the first une, Moore says, 73 percent of the people admitted some member of their family suffered from emolional prublems, apparently induced by the tomado. The second tornado was nnlder, and resulted in more than half of the people with this com-plaint. Sampíe emotional íllS: One woman develuped a limp although her doctor could find no physlcal cause. Another reported blindness for several days after the storm.
A third experíenced temporary amnesia. Several other pers.«ns reported imexplained weakness, insomnia, nightmarcs, and general depression More than a year after a tornado, one survivor stíll could not use her borne air-conditioner because of the sound c>f air being pulled through it. " (R9)

X18. September 2, 1945. Khumotovo, U.S.S.R. In Chapter GV»F, we cataloged many falls-from-the-sky of fish, frogs, hay, and other creatures ana materials. Usuelly, the contents of such falls are assumed to have been sticked up by vortex-type storms, carried some dis- tance, and then scattered widely over the ground, often at the feet of amazed onlookers. Al least, we would expect that active wind vórtices would be good scatterers of their contents.

D.V. Nalivkin, however, has collected evidence that in at least sume cases the levitated objects and materials are transportad through the ntmosphere in small. compact masses, relatively intact, just as they were sucked up. They are then dropped in an urea roughly the size of that where they originated. This defies common sense.

Nalivkin gives severa! specifie nnee- dotal examples, *Me* choose two for inclusión here. stacked hay (below) and the contents of a small pond (XI9).

"On September 2, 1945, to the north of Moscow, in the village of Khumotovo, a stack of hay was lifted up by o tornado. After some time the compact mass of hay dropped from the cloud 3 km to the side of the traek of the tornado, whose width was not more than 300 ni."

The dense stack of hay was trans- poted a total of 5 km and dropped to the ground as a compact, undíspersed mess. (RII)

X19. 1927. Serpukhov, U.S.S.R. "In 1927 , not fnr from Serpukhov, a tornado sucked up a small pool with its entire population. After a few kilometers, orí the outskirts of the eíty, the pond with all the fish and frogs was dropped from the cloud, over quite a small aren. The pool was transportcri in the foro, of a compact unit." (RII)

The "compact-mass" theory of trar.s-portntion is nt odds with many of the falls reported ir. Chapter GV/F. where

rr.ost fallf coiisist onlv of one species of animal nml no other naturallv associ ated animáis, vegetation. or inanimate debris.

Ref&rences

Rl. "Phenomena of Storms," Scientific American, 22:302, 1370. (XI)
R2. Smith, George Clinton; "Cyelones and Tornadoes," Popular Science Monthly, 23:743, 1883. (X2)
R3. "Trombe," Ciel ot Terre, 14:144, 1393. (X4) (Cr. L. üearhart)
R4. Lewis, F. Park; "Freaks of the Tornado, ᴹ Sci^nUfic_Amejúca^, 92:423, 1905. (XG)
R5. Walsh, George F. ; "Freaks of the Tornado, " Harj)er^s_WeekI^, 57:25, May 17, 1913. (X3)
R6. Meisinger, C. LeRoy; "Tornadoes," Science, 52:293, 1920*. (X16)
R7. "Tornado Freaks," American Meteoro- logical Society, Bulletin, 14:118, 1933. (X9)
R8. Flora, Snowden D.; "Freaks oí the Storm, " Tornadoes of the United States, Norman, Oklahoma, 1953, p. 13, 7b. (X5, X7, X8, X10, Xll, X12, X14)
R9. "F'inds Mental ílls Are Aftermath of Tornadoes, " Science Digest, 43:20, May 1958. (X17) '
RIO, Galway, Joseph G., and Schaefer, Joseph T.; "Fowl Play, " Weatherwise, 32:116, 1979. (X13, X15)
Rll. Nalivkin, D. V,; Hurricanes, Storms and Tornadoes. New Delhi, 1982, pp. 432-435. (X18, X19)

GWT8 Tornado Incidence Correlated with Magnetic Variation

Üescription. The tendeney of tomados to be more írequent along lines of 8-10° magnetic variation, at least ín Missouri, where a study was made.
Data Evaluation. One oíd analysis írom a limited geographical area. Rating: 3

Anomaly Evaluation. Any cause-and-effect reiationship between the variation of tr>e earth's magnetic field and tornado frequeney would be startling in terms of present meteorulogical theory. Rating: 2.
Pos si ble Explanations. Trends in magnetic variation may be related to geology and topology, which ín turn naght affect tornado development.
Similar and Reiated Phenomena. Geography strongly influences weather. as exemplified by "Tornado Alley" ín the American midwest.

Examples of a Reiationship between Tornados and Magnetic Variation

XI. Statistical analysis. "The following may be *oí* interest as lo the possible rtla tion between tornadoes and whatever causes variation of compase 1 he variation in Missouri was determined by a magnetic survey made by Prof. F. E. Nlpher. Fhe number of tornadoes was obtaíned fiomSig nal Service publications, Missouri Weather

Reports, rtewspapers and individuáis. None but genuine twisters were Usted. The grea test variation is in the extreme N. W. part ol the State, the least in the S. W.

On the line of:

11° variation	3 countles had	7 tornadoes
105	15	
9	?G	22
S.3	18	13
8	14	?

References
Rl. Llewellyn, J. F.; "RelaUon between Tornadoes and Variations of the Com-nass.[11] American Meteorológica! Joar-nal, 4:135, 1887. (XI)

GWT9 Landspouts or Dustspouts

Doscription. The formation of the waterspout's tvpical hollow tube from dust and snnd raiher than water and mist. In contrast to dust devils and whirlwmds, a parent cloud is present. On the other hand, except for its marked tubular structure, the dustspout ¡s very tornado-like and may. in fa- t, be iust an unusual subspecies of tbls phenomenon.

Data Evaluation. A single but well-observed example. Rating: 3.
Anómala Lvaluation. The dustspout is eurious fur its hollow-tube structure, which is much more ohvious than Ln a normal tornado. Otherwise, it seems no more mysterious than the ordinary tornado. Rating: 3.

Possible Explanations. Ixistspouts are probably just weak tornarlos.
Similar and Reiated Phenomena. All tornados, waterspouts, dust devils, and whirlwinds. (GWW /.

Examples of Dustspouts *

XI. December 27, J935. Persia. Descrip- tion of a "waterspout" formed of dust 150 miles from the nearest sea. "Its distance from myself as observer was about two miles, and it was viewed through a pair of Zeiss glasses with a magnification of etght. As the pendant gradually dropped from the cloud, a hollow column of dust from the plain rose Lo meet it. The pendant and column eventually joined, the whole swaying about in a particularly beautiful marmer. The height of the column from the plain to the cloud was about 2,000 feet, and the mo- tion of the column about fifteen miles per hour but very irregular. 1 have no note on the direction of rotation uf the column. The whole phenomenon lasted about fifteen minutes, and tfie pendant portion withdrew into the cloud first, leaving the lower portion rotating at the bottoni. At the base of the column there was a f..untain of large frag-

ments thrown out, stones, sticks and any- thing that was luose. The whole column ap- peared like a translucent glass tube, but flexible, that ís, there was a dark edge and a brighter middle.....A solid column of mist would have gíven an exactly opposite effect, namely, a dark middle and a bright edge. There is no doubt in my mínd at any rale that the column was hollow[1], and that the lower part of it v\as composed of dust, which was of a browner colour than the cloud above it. »Such a 'landspout' is, of course, not to be confused with the ordinary dust deviJ, which is quite common in any desert on a bright day." (Rl) Dust devils (GWW) do not have parent clouds. (WRC)

References

Rl- Rusk, II. G ; T I,and Waterspouts," Meteorological Magazine. 01:289, 1927.
(XI)

GWT10 Waterspouts between Clouds

Description. The íormation of waterspouts between two clouds rather than from cloud to water.

Data Evaluation. Ünly two observations have been uncovered in the meteorológica] litera- ture. The observations are difficult because it is often impossible to determine whother the funnel-like structures are eomposed of water or are simply clouds. Rating 3.

Anomafy Evaluation. Waterspouts or funnel clouds between clouds can be classified as un- usual but there seems to be no theoretical reason why vortexes cannot form between clouds, even Lo the point of une drawing vapor from another. Rating: 3.

Possible Explanations. The chance connection of two clouds by a funnel or vortex, perhaps encouraged by different meteorológica! conditions existing at two cloud levels.

Similar and Related Phenomena. Horizontal funnel clouds <GWT3), which sometimes end in mid-air; cloud arches (GWC2), which connect widely separated clouds.

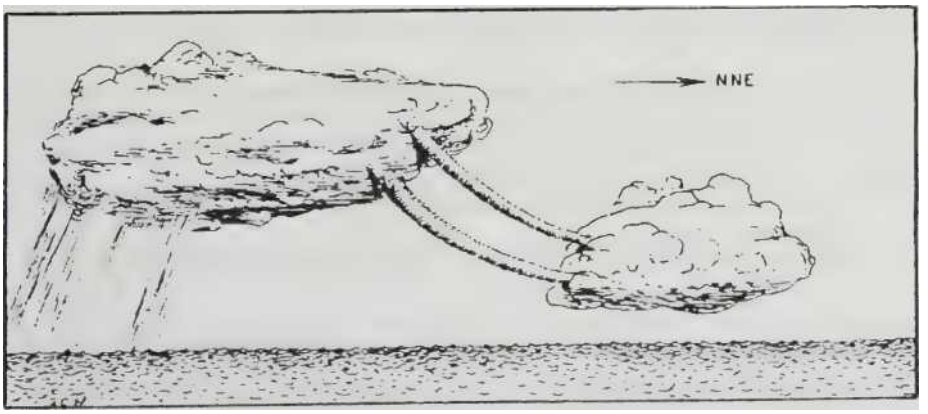
Examples of Waterspouts between Clouds

XI. May 10, 1028. South China Sea. "Sky three parts clouded with heavy Cumulus, Rain squalls around the horizon. Observed peculiar cloud íormation tu Eastward. Alti- tude about 3500'. It appeared as if a heavy rainfall was taking place from one cloud to another. It was quite apparent that no rain was falling inte» the sea. This rain was 'funnel—shaped, and it is considered that asmall vvaterspout had formed in the sky and was sucking rain from a heavy cumulus cloud to another cloud (small, fluffy and whitish) above it. " (Rl)

X2. June 14, 1928. North Atlantic Ocean. ", . .at 1. 55 p. m. , a nimbus cloud bearing W, **N.** W. and moving **ínaN.N.E.** 'ly direction was observed to be connected to a bank of cumulus cloud by two waterspouts, whichdid not reach sea, but merely stretched between the two cloud-banks, " <R2)

References

Rl. Haselfoot, F E. B. ; "Cloud Phenomenon, " Marine Observer, 0:102, 1929. (XI)
R2. Major, T W.; "Waterspouts between Cloud,'[1] Marine Ubserwr, 6:127, 1929. <X2) '



Tm< waterspouts hnkmg two clouds over the North Atlantic (X2¡

GWT12 THIN WATERSPOUTS

GWT11 Forked Waterspouts

Description *A* single waterspout funnel that splits into two diverging branches.
Data Evaluatiun. A solitary example has been found, which is weakened by the possibility that a closer spout may conceal the upper portion of a second, more distant spout, maklng , it seem as If the first spout possesses two lovver branches. Rating: 3.

Anpmaly Evaiüation. Forked waterspouts, if a faet, present serious problems in explana- tion, because át the fork there would seem to be two vortex walls rotating in opposíte direc- tions. Rating: 2.

Possible Explanat ions. Forked waterspouts may be simply illusions due to perspective and bad seeing.

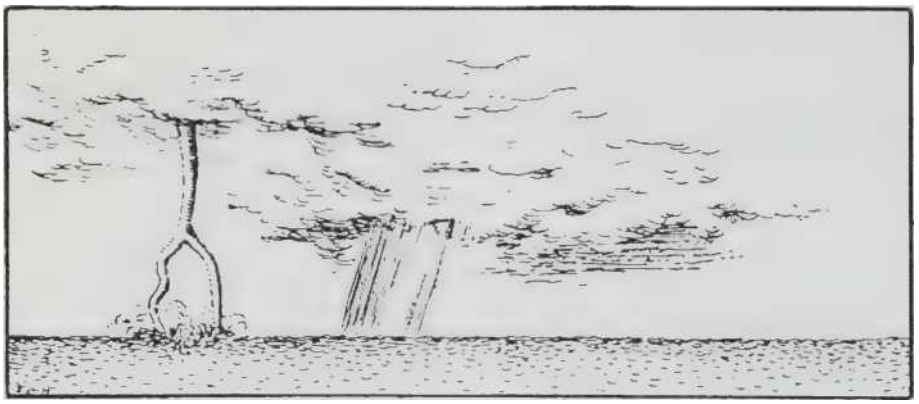
Similar and Related Phenomena. None.

Examples of Forked Waterspouts

XI. May lí^, 1967. South China Sea. "A waterspout which divided into two branches about half-way between the cloud base and the sea, as shown in the sketch, was seen at 0715 LMT about 10 miles off. The two parta joined together about 10 min later to form a single column, at the base oí which greai turbulence was observed." (RI)

References

RI. Rippon, R.G.; "Fc-rked Waterspout, " Marine Observer, 38:62, 1968. (XI)



A forked waterspout observed tn the South China Sea (XI)

GWT12 Abnormally Thín Waterspouts

Description. Waterspouts with very thin funnels (less than 1 íout ín día meter) or very low diameter-to-height ratios (less than 0.01).

Data Evaluatiop. A few accounls of rather poor quality have been found. One difficuity here is that the visible dimensions of a waterspout, as defrned by the spray and vapor, may not mark the true bounds of the atmospheric vortex. Rating: 3.

Annnialy Evalnanon. Aimuspheric vortexes can be almost any diameter----------therc seem to be nu physicai reslrlctíons--------but it is remarkable to find stablc waterspouts a hundred times their diameters in heighi. at k-ast from the standpoint ol stabiiity. Rating: 3.
Possible Explanations. H may be that our physicai expectations are faully he re and natural vortexes are much more stable at very low diameter-to-height ratios than we predict from Lntuition. Another possibility is the presence of an unappreciated stabilizing factor, such as an electrieal discharge.
Similar and Related Phetiomena. Other atmospheric vortexes may aiso display low diameter- to-height ratios (indeed, we would expecl them to based on the similarity of tbe phenomena). bul so far we have lound no such records.

Examplcs of Abnormally Thtn Waterspouts

XI. May 16, 1898. Edén, Australia. "The longest recorded walerspout occurred otf Edén, Australia, on May 18, 1898. Pilut Nc-wton describe*! it as being 'straight as a shaft' and 'thirty times as high as a **Clipper** ship.' Theodolite measurements **verified** its actual height at 5, 01 i feet—nearly a full mile above sea level. Central funnel dia meter, however, was a mere ten feet. "(RI)

X2. December 18, 1917. Rabal, Morocco. Spout 1000 feet high, but only 3 inches in diameter. (RI)

Refercnces

RI. Mooney, Michael J. ; "Sea Squirts, " Oceans. 6:42, May 1973. (XI. X2)

GWT13 Waterspout Funnel-Knots

Uescription. The appearance of knots or bulges at irregular intervals along an otherwise uniform waterspout funnel.
Data Evaluation. A single **report** casually mentions the existence of this phenumenon. Rating: 3.
Anomaly Evaluation. Waterspout theory dees not predict funnel bulges, but sald theory is based upon uniform atmospheric conditions. It is conceivable that waterspoutdiameters may expand as atmospheric parameters change at varíous altitudes. Rating: 3.
Possible **Expl** anal ion s. Varying atmospheric conditions (temperature, pressure. humidity, wind veiocity, etc.) aíong the spout's funnel may díctate different funnel dlameters.
Similar and Related Phenomena.

Exampies uf Waterspout Funnel-Knots

XI. General observations. "Other strango aberratione have produced 'funnel-knots[1] at irregular intervals, a great bulge in the upper funnel, and a classic 'hourglass' shape." (RI)

References

RI. Mooney, Michael J."Sea Squirts Oceans, 6:42, May 11G3. (.)

GWT14 Bull's-Eye Squalls or White Squalls

Descriptiori. Slrong vórtices or squalls that descend vertlcally. sometimes trom a olear sKy- Some are presaged by the appearance of a bright región overhead.

Data Evaluation. Severai **reports** in **Science** magazines of strong downbursts and **gTound-level** damage in **different parts of** the **planeí.** Rating: 2.

Anomaly Evaluation. Vórtices and strong turbulence invisible to the naked eye are well known to atmospheric scientists and to aircraft pilots; e-g-, CAT or "clear-air turbulence." However, strong downbursts capable of leveling large areas of forest are phenomena not fully explamed. Rating: 3.

Similar and Related Phenomena. Clear-air turbulence; the explosivo onset of whirhvinds (GVVW1). Some devastated forest areas, partícularly in South America, have been attributed to meteor impacts. They could, however, be due to strong downbursts. (See p. 177 in Science Fruntiers II.)

Exarnples of Bull's-Eye Squalls

XI. General observatíons. "Undoubtedly the most dangerous spe ut of all ís the dreaded 'Bull's-Eye Squall' ur 'White Squall.' Slater Brown explains that: 'On rare occa- sions, when the air is too dry to produce water in a spout, though all the uther condi- tions are pre9ent, there cccurs what is known as a white or Dull's Eye Squall.... The Por- tugese describe a Bull's-Eye Squall as first appearlrg like a bright white spot at or near the zenit!), in a perfeetly clear sky and fine weather, and which, rapidly de6cendLng, brings with il **.1** furious w'bite squall or tornado. They generally occur off the west ccast of Africa. " (Rl)

X2. August 1, 1984. Andrews Air Forcé Base, Maryland. Called a "microburst", the following phenomenon resembles the bull's-pye squalls.

"...a strong downdraft that causes wiiids to spreorj out in a ring-like pnt- te'Ti as they reach the grounü... .oc- curred last August 1. (T.T. Fujita'sJ studv reveáis the strongest r.ncroburst cvcr recorded happened only six minutes ftfter Air Forcé One landed at Andrews Air Forcé Base near Washington. The winds measurea near the end of the run- way exceeded 130 knots, or about 149 miles per hour." (R2>

X3. Occasional occurrence. Brazil. "Scientists studying weather patterris in the Ar.iazon Basin have detected ex tremely powerful, sudden bursts of wind over the rainforest. The winds, which appear to be associated with thunder- storms in the northwest part of Brazil. blow downword with tremendous forcé. Sntellit^ photos indícate that a single episode deinolished 10 square miles of jungle in only 20 minutes," <R3)

Referen ces

Rl. Mooney, Michael J.; "Sea Squirts, " Oceans, 6:42, May 1973. (XI)
R2. Simón, C.; "Record-Breaking Microburst near Air Forcé 1," Science News, 126:36, 1984. (X'2)
R3. Anonymous: "Puzzling Winds," 1NFO Journal. t)74-39, 1996 (X3)

GWT15 Tornado Onset Correlated with Intracloud Lightning

Deseription. The appearance of tornados during or immediately following high ratios of intracloud lightning discharges to cloud-to-ground lightning discharges.

Data Evaluation. As of 1995, only one report of the phenomenon in a popular Science magazíne. Rating: 3.

Anomaly Evaluation. The subject correlation is unexplained. Is it just an acausal correlation or does the intense intracloud lightning actually initiate the formation of a tornado? Rating: 3.

Similar and Related Phenomena. The apparent reduction of cloud-to-ground Lightning near tornados (GWT1-X13).

Entry

Xl. April 17, 1995. Oklahoma. On this date, the Optical Transient Detector satellite passed over an Oklahomn thunderstorm. The satellite recorded thot there were 20 times more cloud-to- cloud lightning discharges than cloud-to-ground sírikes. Normally, the ratio is 3:1 or 4:1, according to ground obser- vers, who of course have a more limited view of storms than satellites.

About a minute aftcr the satellite hsd passed o ver the storm, a tornado emerged from the cloud.

"The new satellite results suggest that a thundercloud is liktly to spnwn a tornado when an unusuall} high propor- tion of its lightning flashes do nrt hit the ground " (Rl)

Reference

Rl. Hecht, Jeff; "Tornado Watchers Get a Flash of Inspiration " New Scientist, p. 17, Octobe[1] 7, 1995. **(Xl)**

GWT16 Anomalous Fallout of Debris from Tornados

Deseription. The long-distance transport of tornado debris and the preferred pattern of its deposition along the storm track.

Data Evaluation. A lengthy. comprehensive study published in a mainstream Science Journal, Rating: 1

Anomaly Evaluation. Meteorologists are uncertain as to: (1) How debris is trans- ferred from the tornado proper to the mesospheric circulation; (2) Why tornado- carried debris tends to be deposited to the left of the storm track; and (3) Why a "preferred" band of debris deposition exists. Rating: 3.

Similar and Related Phenomena. The counterclockwise circulation of low-pressure cyclones in the Northern Hemisphere;

GWT16 TORNADO FALLOUT DEBRIS

Entries

XI[a]. Introduction. Tornados, like Jight- ning and earthquakes, are examples *oí* the extremely powerful forces Nature can raisr on onr planet's surfare When contempla ting tornadic forces, Science writers usually focus on the darnoge done along the storm's ground track: the demolished buildings, the number of deaths, and attention-grnbbing pheno- mena, such as straws driven endwise into telephone poles.

A less-publicized phenomenon----one of more scientific importance—is the distnnt fillout of debris swept up by strong t< rnados. How far is debris car- ried? Hc"« heavy is it? What are the fal]- out potterns? Answers to such questions give us clues to tornado structure and its Ínternetions with larger-scale atmo- spherie activity, such as mesospheric circulation.

XI. Tornado fallont studies. Comprehensivo, far-rangTng studies of tornado fall- out are scarce. Anécdota! reporta, in contrBst, are common, such as shingles being dropped 5 miles nway. This eatalog entrv is based upon a 1995 survey by J.T Snow et al published by the American Meteorological Kociety. It is based upon data from over 10,000 North American tornados.

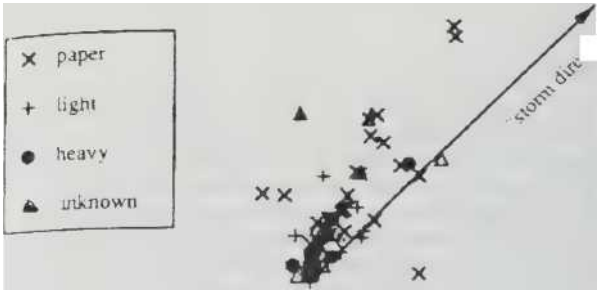
Snovv el al first established three categoríes of fallout:

(1) Trnceable paper (checks. letters. invoices, etc.)
(2) Treceable light objects weighing less than One pound (shingles, bank pouches, bundles of caneelled checks, etc.)
(3) Traceable heavy objects ovar une pound (pieces of plywood, aluminum siding, household ítems, etc.)

Their lengthy survey yiekled three "conjectures" and a unique summary graph illustratíng fallout patterns.
(See accompanying figure.) VVe now quote from the first two conjectures. [1]

(1) "Debris, sometimes large pieces, rioe[c] falJ from some tornadic storms weil downstream from its source. While most lofted material falls out locally, we sus- pect a small omount of debris is carried upward in or around the tornado core and transferred into the circulation of the mesocyclone. The rising oir in the mesocyelone apparently cRrries the material still higher into the parent storm • Kxactly how high material is lofted and how the transfer occurs re- moins unclear."

(2) "Consisten! with Anderson's findings, composited historical data con- tains hints that there is organizaron in how fallout occurs downstream. The large majority of historical accounts of long-distance transport of debris place the fallout to the left of the direction of storm movement. There is aleo a sug- gestion of a concentrated band of material wíthin the overa!! fallout pattern..." (R1)



I) SO 100 ISO 200 250 mi

*Composite. pattern of fiS debris reporls from 31 tornadic storms, Debris **fallout ítems are** plotteó by distances from their sources **and** distantes from the storm **track. Note** tlie **leftward** trend and the sugyeslion of **a** fuvnred band. (RI)*

X2. November 10, 1915, Great Bend, Kansas. This F4 tornado gives us 8 fascinating collection of long-range fallout anecdotes.

"Figure 4 (not reproduced) suggests that most heavy debris falls out within 50 miles (80 km) of its source. while most light debris falls out within 90 miles 1.145 km) of its source. Paper debris. on the other hand, can be depo- sited much farther. The farthest re- ported distance for any fallout is 210 miles (335 km); this was a caneelled check, found in Palmyra, Nebraskn, transported by the thunderstorm that

produced the 1915 Great Bend tornado. Thís tornadic thunderstorm also trans- ported llght and heavv objects farther than any other storm on record. Clothing, shingles, cnd fragmenta of books were found in Glaseo, 87 miles (140 km) to the northeast ol Great Bend. A saek of flour, categorized as hoavy, was found 110 miles (175 km) to the northeast."
<R1>

Reference

RI. Snow, John T.,t et al; "Fallout of Debris from Tornadle Thunderstorms: A Histórica! Perspective and TMIO Ex- amples from VORTEX." American Meteorológica] Society, Bulletin, 76: 1777 1995. ÍX0-X2)

GWT17 Tornados Correlated with Oil Deposits

Description. The correlation of tornado origins and areas whcre gas and oil deposits exist.

Data Evaluation. A newspaper account of a paper presented at a meeting of the American Geophysieal Union. The claim is based only upon a correlation. No physical evidence was presented. Rating: 3.

Anomaly Evaluation. Mainstreain science seems to hnve rejected this claim without further investigation. Since tornado génesis is deemed to be purely meteorológica!, the claim that subsurface geological phenomenn ma> be involved is anomalous. Rating: 2.

Similar and Related Phenomena. The correlation between the loeations of spon- tañeous wüdfires, geological fault networks, and coronal mass ejections. (GWI2-X2)

Entry

XI General observations. Sometimes obscure and unlikely correlations lead to new insights. In this context, we are obliged to mention a most improbable connection proposed by Chemical engineer S. Morí in a paper presented at the Spring 2000 meeting of tlie American Geophysieal Union, Morí suspeets that ol] and gas deposits are linked to the origin of tornados!

"In his paper, Morí said that post- tively charged oil deposits underground establish polarity wíth negativclv charged oxygen ions at the surfuce. When a thunderstorm posses over the oil field. he thinks this subsurface polarity links up the wlth electric polarity estoblished between clonds and ground, creating the vacuum that spawns the tornado.

"ÍJvi[ir the years, Mori said he's built a data base of about *,000 tornado hits in the United States for comparison with the locatíon of known oil and gas deposits. He said that studies in Kansas Pennsvlvanla and Texas found a high correlation." (RI)

Reference

RI. Lore, David, "Underground Gil Une Twist in Tornado Theory," Charleston (VVV) Dispatch, June 8, 2000. Cr. J. Dotson. <\i)

GWT18 Enigmatic Geyser-Topped “Waves”

Description. The appearance during heavy seas of «ave Ilke structures topped by several thin geysers. This phenomenon is totally enigmatic.

Data Evaluation. Testimony of a seaman dating back to 1934. Obviously, caution must be used here. Rating: 3,

Anomaly Evaluation. The "family" of small geysers atop the giant wave-like stiructure has no known counterparts that we know of, and no explanation either' Rating: 2.

Similar and Related Phenomena. Families of whirlwinds and dust devils (GWW6).

Entry

XI. Spring 1934. North Pacific Ocean. Report from the freighter Cape Horn enroute to Singapore.

G. Craig ivas thP helmsman on the Cape Horn during a powerful storm (winds of Forcé 9-10, seas running 8 meterá high). Even at 4 A.M., the phos- phorescence ot the breaking sea made it seem like duylight.

At 4:3<I. Craig saw what he thought wos a colossel wave forming. 11 was so largo that the vessel seeined certain to capsize. He thought he was ti goner. Rut, strangely, the "wave" closed with the vessel very slowly and seemed to move independently of the rest oi the stormy sea. Craig recalled other strange feutures of the phenomenon.

"...what i had initially mistaken for wave crests were actually widely-spacvd 'geysers', dancing on the upper surface and each rising to a height of about 20 feet, dropping to half of it, then rising again." JSee Craig's accompanying sketch.]

Then, suddenly, when all seemed lost, the wind dropped from a fu 11 galo tu an ecrie calía. The "wave" passed-----gently ----and then the storm resumed.

The Cape Horn was drenched, but there had been no shaltering of glass ñor rending of wood. There was some flouding but no more thnn usual in very heavy seas. Some of the lamber lashed to the deek had been lost, but, over all. darnage was minimal, The seemingly cats- stropic "wave," topped by the peculiar geysers turned out to be only a hollow threat. and the "wave's" hollowness may be a clue to its true noture, (RI)

Indeed, hollowness is characteristic of waterspouts. They are fierce on the out- side but calm inside. One senses an irnpending catastrophe but in the end there is only a gentle passage through the spout. The Cape Horn had apparent- lv been hit dcad on by a waterspout.

Rut the strange geysers atop the 'wave’ or spout deserve an explanation that we cannot provide.

Reference

RI. Craig, Gavin; "Surviving a Giant Sea---Did the Ship Strike n Water-spout*'" Journal of Meteorology (U.K.), 25:241, 2000. oXI) "

G. *Craig's sketch of the* ***ominmis "vove"*** *topped by several "geysers. " The passage through the phenomenon was sur prisingly gen lie.*

GWW WHIRLWINDS AND DUST DEVILS

Key to Phenomena

GWWO Inlroduction
GWW1 The Explosiva Onsel of Whirlwmds
GWW2 Pranks of Whirlwinds and Dust Devils
GWW3 Steam Devils
GWW4 Electrical Properties of Whirlwinds and Dust Devils
GWW5 Energetic Miniature Vortexes
GWW6 Group Organizaron of Dust and Spray Devils
GWW7 Sounds of Atmospheric Vórtices

GWWO Introduction

Whirlwinds and dust devils are rotary disturbances of the atmosphere llke tornados and waterspouts, but they are less energetic and often seem a different class of phenomena al- together. The playful vortex that spins up a cloud of leaves on a sun-warmed hillside or tosses a farmer’s hay up on the telephone \vires is certainly less fearful than the death-dealing tornado that can drive a straw into a telephone pole like a nail. Size and strength are the obvious differences between these classes of vortexes. Another salient feature of whirlwinds and dust devils is their fair-weather occurrence. Unlike tornados and water-spouts. they appear on simny days without menaeing clouds overhead. Their pranks are legend, but they are not entirely harmless either. The larger whirlwinds may be violent enough to rip off roofs; rarely they generate their own thunder and lightning. Even a small whirlwind a couple feet in diameter can upset lawn furniture and cause considerable mis-chief.

Whirlwinds and dust devils are set in motion by rising columns of warm air that are some-how invested with rotary motion. No one knows if electricity is important Ln starting these vortexes, but electrical phenomena are often present; viz.. lightning and electric-field variatlons. Qn rare occasicns, whirlwinds seem to be born violently with a sharp, explosiva sound, the precise source of which is uncertain. Once in motion, they seem to have líves of their own and do not expire easily. Dust devils, those denizens of hot desert expanses, not onlv persíst but may spawn progeny, or line up with other devils and march aíong in formaüon. Spiral dust-devil tracks are well known. But such amusing aspects of vortex behavior are not sufficiently anomalous to be tncluded in this Catalog.

Finally, a special type of vortex called a "steam devil" maltes its appearance in this chapter. Seen when the air témperature is much lower than water temperature, steam devils frequent- **IV** reach hundreds of feet into the air to join clouds overhead—much like tornados and water- spouts. Despite the similarity, the steam devil is a mild-mannered vortex, possibly a hybrid between the whirlwind and the waterspout; and we inelude it in this sectic-n aiong with the other less energetic vortexes.

GWW1 The Explosive Onset of Whirlwinds

Description. The tendency of small but obviously eoergetie whirlwinds to begin suddenly, without warning, "out-of-the-blue, " often with an explosive sound or a noise akin to distant thunder. Usually, the skies are fair and winds calm before the phenomenon begins.
Data Evaluatíon. Surprisingly, sudden and noisy debuts of whirlwinds have been recorded rather frequently. Rating: 1.
Anomaly Evaluation. The typical whirlwind is thought to origínate when the warm sun causes convection currents, turbulence. and the subsequent formation of vortexes. AJl of the small lazy whirls of air seen in woods and fields are probably of this type. The explosive
commencement of whirlwinds---e8pecially accompanied by a detonation is not in accord with this suríace convection hypothesis. Something more seems required (see below), but it is not likely that current theory will have to be bent very far. Rating: 3.
Possible Explanation. Since the affeeted area is usually calm prior to the appearanee of the whirlwind, it is possible that the vortexes may form aloft and descend suddenly to the sur- face, perhaps suddenly enough to generate considerable sound.
Similar and Related Phenomena. Bull's-eye squalls (GWT14).

Examples of the Explosive Onset of Whirlwinds

XI. June 2, 1779. Aberdeenshire, Seotland. "The 2nd of June (1779) sittlng by the water we saw a pillar of water rise as high as the tallest tree, and fall down again, afterwhich it rolled along for a considerable space in large rolls as if a cask had been under the water, (and out of thuse rolls sprung up small strings of water, rismg pretty high,
as out of the strup of a razar)- The noise it tnade was such as a firework of powder makes when first set off, but much louder. The day was clear, fine sunshine and not a breath of wind. " (RIO)

X2. June 29, 1842. Cupar, Seotland. "About half past 12 o[1] dock, whilst the sky was clear, and the air, as it had been throughout the morning, perfectly calm, agirl employed in tramping clothes in a tub in the piece of ground above the towm called the common, heard a loud and Sharp report overhead, suc- ceeded by a gust of wind of most extraordi- nary vehemence, and only of a few moments duration. On looking round, sbe observed the whole of the clothes, sheets, &c, lying within a line of certain breadth, stretching across the green, severa! hundred yards distant; another portion of the articles, how- ever, consisting of a quantity of curtains, and a number of smaller articles, were carried upwards to an immense height, so as to be alniost lost to the eye and gradu- ally disappeared altogether from sight in a south-eastern direction and have not yet port which preceeded the wind, the eaitle in the neighboring meadow were observed running about in an affrighted State, and for some time afterwards they continued cowering together in evident terror. The violence of the wind was such that a woman, who ai the tíme was holding a blanket, found herself unable to retain it in fear of being carried along with it. " (RI)

X3. Circa 1879. Signy-le-Petit, France. "The weather was clear, there were no clouds, the air was coid, but stíll; there was not the least sígn of wind. At Signy is an ísolated huuse occupied by one named Chailloux-Binet. It is ibuilt ot stone and roofed with slate. Suddenly a dull sound was heard, aomewhaí like the rumble of a carriage drawm by a horse at full gallop, then a w'hirlwind of irresistible forcé was formed, which suddenly and instantaneously carried off the roof of the house, and dis- persed It in all directions. This whirlwᶠind was neitber preceeded ñor followed by any rain. It is ailso extraordinary that this house alone was affeeted, and at ten metres distance no disturbance of any kind was ex- perienced. " (R2)

X4. September 3, 1879. Montgomery County, Maryland. *A* small but destructive whirlwind began its course with a roar. Several people heard sounds like explosions during its progress. <R4)

X5. Circa 1880. East Kent, Ontario, Cañada. Two men were in a fíeld ",.. when they heard a sudden loud report, like that of a cannon.

They turned just in time to see a cloud of stones flying upward from a spot in the fie3d. Surprised beyond measure tbey examined the spot, which was circular and about 16 feet across, but the re was no stgu of an eruption ñor anything to indícate the iall of a heavy body there. The ground was simply swept clean. " (R3)

X6. August 27, 1886. Lough Neagh, Northern Ireland. "While standing with Mr. S. A. Stew- art in a recently-mown meadow, near Port- more Lough, on the eastern sitie of Lough Neagh, our attention was attracted by a rum- bling noise. The day was very fine and warm, and dead calm, nc.t a leaf stirring, and afew very light clouds were in the sky. The noise was like a short distant peal of thunder, but sounded faint rather than distant. While we watched, a whirlwind suddenly appeared in the direction whence the sounds had come (the north), and at a distance of about a hun- dred yards from us. A quantity of loosehay was instantly whirled upward to a height of about 100 feet, and, after floating about in eircles, slowly settled down. A haycock at the spot was much disturbed, and presented the appearance of havmg endured a gale of wind. The time betweeu the rumbling sound (which closely resembled the distant report ol a cannon) and the appearance of the whirlwind was about half a minute, and the whirlwind lasted somewhat over a minute. ” (R6)

X7. .Tune 21, 1894. Reigate, England. A clear and brilliant day, no wind stirring- A violent whirlwind appeared without warning withín a few yards of the observar, carrying hay to great heights. " (R5) XS. 1918. Launceston, England. A small localized whirlwind attracted the attention of observers because it made a noise like distant thunder. (R7)

X9. October 20, 1949. Shoeburyness, Eng- land. ".Mr. Whitaker, who happened to be outside his office at the time, said that while watching what appeared to be a frontal cloud he heard a muffled sound like distant thunder or an explosión, and on turning to the south-west saw that at a distance of about 1,000 yd. the air was filled t>' a con- siderable height with le a ves, twigs and similar light debris swirling violently ai though after a large but smokeless explosión. He called nut two other observers, who sawthe subsequent events with him. Almost atonce the wind increased to gale forcé, torrential rain began to fa.ll, añil the debris, now quite dense and only a few hundred yards away, was travellíng towards them from a south- westerly direction and was observed to be rotating from left to right, i.e. counter- clockwise. The disturbance very quiekly arrived where they were standing. Tall trees in leal were bent over and thrashed about wildly, and one or two broke. These trees had trunks about 1 ft. in diameterand were about 30 ft. high in a row across the path oí the disturbance.. .. .The disturbance was all over in about a minute and tbe heavy rain ceased almost at the same time. The damage was confined to a narrow track about 100 yd. wide or less. " (R8)

X10. September 3, 1955. Pilsden Pen, Eng- land. IXiring a picnic. "Suddenly at about 1305 BST a sound was heard from the west like sand being loaded into a truck. But only a level stretch of coarse grass was to be seen. Some oí the grass in the direction of the sound was then observed to be moving and becoming flattened, while bits of paper were seen whirling in the air, though the wind was light where the party was. In a few seconds the miniature whirlwind was up- on the picnickers. II removed a small paper bag, and lifted un an umbrella which had been left open on the ground. Thts was moved in an anticlockwise manner awaj north-east- wards over the earthen rampart of the pre- hístoric íort and about twenty feet up into the air. " (R9)

XII. June 16, 1988. Avebury, I’níted Kingdom. Vapor vórtices or vapor whírl- winds sometimes appear and dissipate suddenly R. Lucas, a famiworker, apparently saw a phenomenon of this ty'pe in a wheatfíeld in th» summer of 1988. Here is what he reported.

"Looking across the fieid of wiriter wheat to the east..., he suddenly notieed at a distance of HI metres— what he took to bt a large puff of white ’bonfire smoke^{T} risxng to 15 feet (5m) máximum height The outer part of this 'smoke’ column was scareely rotating hut the middle part. which was too thick to see through, was spinning rapidly. In a couple of seconds the effect had ended; the spinning central column had gone and the residual 'smoke' or cloud of fog drifted gently in the prevailing light north-east wind towards the south- West and dissolved after going severa! yards. He used the word smoke out ol conveni- ence but said that the effe<t was more likely raused by water vapour, cloud droplets *>r fog. tk further eniphasized the swiftness of the appearance and dis- appearance ol the phenomenon. ti had arrivml suddenly like ’f-mokc from a dis- tnnt cannon' «>r just as i' 'a smoke-filled

or fog-filled bnlloon hsd suddenly burst ’ That is to ssy, it emerged as if from nowhere. He made the iurther point that the spinning eolumn miglit have been very much longer than he could judge, for he realized that the only part he could see was the part rendered visible by the smoke or fog. The diameter of the cloud was abou! the same as its height. viz 4 or 5 metres."

The same phenomenon appeared again a few seconds later, and still again 5 minutes later. (Rll)

References

RI. "Singular Phenomenon,[1] London Times. July 5, 1B42. (X2)
R2. English Mechanic, 29:262, 1879. (X31
R3. "A Curious Phenomenon, " Se i en ti fíe American, 43:25, 1880. (X5)
R4. Farquhar, William Heury, and Hallowell, Henry C,; "A Miniature Cyclone, " Popular Science Monthly, 18:264, 1880. ÍX4)
R5. "A Whírlwind in Surrey," Symons's Monthly Meteorological Magazine. 20: 90, 3894. (X7i
R¡3. Praeger, R. Lloyd; "Barisal Guns and Similar Sounds, " Nature, 53:2%, 1896. (X6)
R7. Rogers, R. B.; "Local Whírlwind, ” Symons's Meteorológica! Magazine, 53: 68, 1918. (X8)
R8. Hemens, L. G,; "Whírlwind at Shoeburyness, " Meteorológica] Magazine, 79:256, 1950. (X9)
R9. Ward, CyrilG.;”A Whirlwind, ” Weather, 11:170, 1956. (X10)
RIO. Meaden, G.T.;"A Meteorological Explanation for Sume of the Mysterious SighUngs on Loch Kess and Other Lakes and Rivers, " Journal of Meteorology, U.K., 1:118, 1976. (XI)
RI 1. Meaden, G.T.; "The Vórtices of Vapor Seen near Avebury. Wiltshíre, above a Wheatfíeld on 16 June 1988," Journal of Meteorology (U.K.), 13: 305, 1988 (XI1)

GWW2 Pranks of Whirlwinds and Dust Devils

Description. A catch-all category of curious observalions connected with whirlwinds and dust devils, such as the propensity of these pbenomena to lift up people and Lhings and set them down in unusual places and, more remarkably, the dust devil's "inquisitive" behavíor.

Data Evaluation. Only a few tales have been collected so lar, but they seem authentic. Pro- bably many stories never get inte the scientific literature. Rating: 2.

Anomaly Evaluation. As in the cases of lightning and tornados, the pranks of these small vortexes can doubtless be handled by current theories of aerodynamics and physics. For example, the "¡nquisitve" behaviur of dust devils is likely generated by the observer’s modu- lation of wind pattems. Pranks are fascinating but hardly a challenge to basic scientific laws. Rating: 3.

Possible Explanations. See above.

Similar and Related Phenomena. Pranks of tornados (GWT7); the inquisitive nature of some bal! lightnings (GLBl); ordinary lightning’s pranks (GLL11). The tatter two references are to be found in Remarkable Luminous Phenomena in Nature.

Examples of Pranks Played by Whirlwinds and Dust Devils

XI. Februarv 25, 1911. Bradford, England. A letter to the editor called the report of a girl being killed by a gust of wind prepos- terous and asked for an investigalion. The editor replied: "ActLng on thls suggestion, we communieated with Mr. H. Lander, the rainfall observer at Lister Park, Bradford,

who kindly sent us a copy of the Yorkshire Observer for February 25th, in whieh there was a fairly full report of the inquest on the school-girl who was undoubtedly killed by a fall from a great height in an extremely exposed playground during very gu.-ty weather. One witness saw the girl enter the playground from the school at 8. 40 a. m. , and saw her carried in Ihree minutes later, Another

witness saw the girl Ln the air parallel with the balcony of the schoul 20 feet above the gruund, her arms extended, ;uid her skirts blown out like a balloon. He saw her fall with a crash. The jury found a verdict, 'Died as the result of a fall eaused by a sudden gust of wind.'" (Rl)

X2. No dale given. Egypt. While walking over the desert. "Hearing a swishingsound behind me, 1 turned and observed a large revolving ring of sand less than a foot high approaching me slowly. It stopped a few feet away and the ring, contalning sand and small pieces of vegetable debris in a sheet less than one inch thick, revolved rapidly around a circle of about 12 ft. díamete r while the axis remained stationary, It then moved slowly around me after remainlng in one spot for at least thirty seconds, and slowly died down. ít would be interesting to know if others acquainted with the desert have come across similar examples of a broad, fíat *-ddy. The ancient superstition aniong desert tríbes that these whirlwinds are spirits, called 'afrít' or 'glnni' (the 'ginnt' of the 'Arabian Nights'), would seem to have a reasonable foundation in face of such an 'inquisitíve' apparition," (R2)

X3, Ortober 1990. Bristol, United King- dom. The following aceount is suspect because it ib based on the testimonies of t wo young children. Since it appeared in a Science journal, we decided to in elude it anyway.

"Two ten-year-old girls were playirig with a frisbee in a playing field adjscent to Downend sports centie, on the south- east outskirts of Bristol. in the County of Avon. While throwing the plástic dish, one little girl was surprised when it was suddenly flung back at her by 'sorne invisible forcé'. Next, the two children were enveloped in a 'yellow bubble'.

This bubble apparently gave both girls *b* mild 'shock' and threw them to the ground. While lying on the grasa, both children experienced diffículty in brea- thing. Eventually. the girls managed to 'break out' of the 'bubüle' and run home, very írightened indeed." ÍR3)

Since vórtices — tornados, whirlwinds -—do exhibít electrical properties, we should at least allow for the possibility of h small whirlwind of yellow dust (the "bubble") producing electrical effeets.

X4. 1869. flash ville, 'J ennessee. "In 1869, Harper's Weekly recounted the rather juvenile antics of a waterspout that forined on the Cura herían d River near Nashville, Tennessee. According to the magazine, one hot sutnmer day, a group of a dozen roen and boys, who had wanted to cool off, had hung their clothes on traes and then bogan swirn- ming in the river. Abruptly a waterspout that eventually reaehed a height of seven feet tall formed on the vi ver.

"As the waterspout neared the swim- mers, it shifted eourse, and moved on land ami uneeremomously whisked away not only their clothes huí alan even the trees on which they bad hungí Fortu- natelv for the etnbarrassed swinimers, rescuers carne in reponse to tne loud calis of the men and boys and finally 's sufñcient number of articles of ap- parel were securtri.'" (i»4)

An acnusmg tale, te ti sure, out it should be noted that n< wspapers ana msgazines in 1869 often priníed exagger- tiuns.

References

Rl. Godden, William; "The Tale of-----a Gust, " Symons's Meteorológica! Maga- zine, 46:54, 1911. (XI)

R2. Capes, J.L.; "A Remarkable Whirl- wind, '' Nature, 135:511, 1935. (X2)

R3. Rendall, P.D.; "Did an Electrically Charged Vortex Strike Two Girls in Bristol, Mid-October 1990?" Journal of Meteorology (U.K.), 15:403, 199b (X3)

114. Cerveny, Kandy; freaks of the Storm, New York, -006. p. 265. (X4)

GWW3 Steam Devils

Description. Long fingere nr columns of vapor rising from a water surface and swirlíng up- ward into thc cloud deck. Large arrays of steam devils may forra geometrical patterns. This phenomenon roqaires warm water and very coid air.

Dackground. Even the most casual observer has seen mist rising from water surfaces when thc air is colder than the water. Sailors cali it "sea smoke. " Air currents form it into eerie swirls and eddies. Much more rarely analogs of whirlwinds and vvaterspouts form.

Data Evaluation. A handlul of good observations plus some excellent photos. Rating: 1.

Anomaly Evaluation. Thermal convection obviously gives birth tu steam devils, bul why are thev so stable, considering their thinness and height? Why do they sometimos form in geometrical patterns? Sime tornados and waterspouts have comparable height-to-diameter ratios, the explanation of steam devil formation will probably evolve from present meteorológica! theory. Rating; 3.

Possible Explanations. The theory of atmospheric vortexes is probably adequate to account for the génesis and maturation of large steam devils, The geometrical patterns of devils may arise from the temlency of convection cells, ín both air and water, to assume a hexagonal geometry.

Similar and Related Phenotnena- Dust devils and spray devils may be spawned in groups and dispíay soine geométrica] organization (GWW6); see Phenomena of the Hydrosphere (Chapter GHC in our catalog Earthquakes, Tides...)

Examples of Steam Devils

XI. January 4, 1910. Canandaigua Lake, New York. Bright san, sume loo cumulus clouds, temperature 6ᵘl The surface of the lake was covered by vapoi c aused by the differenee in tempei ufure between the coid air and the comparatively warm water. This vapor, white mist, gathered in spots in masses rising higher than the surrounding mjst. As these masses of vapor reached a height of some twentv feet they appeared to take on a rotary motion and formed them- selves into columns slowiy risrag until their apexes raet the low-lying clouds, where they spread outina funnel shape exactlv as do water spouls. 1 he columns varied from a foot to possibly ten feet in diameter; some of them ascending in a slraight Une and others bent into fantastic curves by the action of the wind. I saw a great number of these mist whirls during a drive uf some two huurs, covering a distance ot ten miles along the lake shore, and as they formed and drifted slowiy across the water, ílluminaled by the rays of the setting sun, they were a beautíful and to me a unique spectacle. ’’ (R1)

X2. Circal932. Grecian waiers. "Prof. (Johannes)Ualther tells of a recentvoyage in Grecian waters, when :t soowstorm was brewing and the waves were high. The coid air striking the warm water caused numerous columns of white vaoor *o riso over the foamy caps of the waves. They hovered momentarily, then were caughl up whirling by the wind, and as they spunaway through the aír it did not require any violent stretch of the ¡magination to see thom as feminine figures dancing in ftlmy draperies. " The professor wondered if these steam devils might not be the origin of the tales of the Daughters of Nereus who danced on the waves and helped endangered tnariners.
(H 2)

X3. January 30, 1971. Lake Michigan off Milw'aukee, Wisconsin. "The period Jan. 30-31, 1971 was intensely coid Ln Milwaukee, the highest temperature reaching only -6°F with west-n* «rthwest winds frequently gusting to 40 mi/hr. Lake snow squalls were present in e.xcelsis along the lee shores of all the Great Lakes. But most interesting was the view from the upwind shorelíne. During both days, one eould see the typical shallow, dense steam fog near the lake surface (water temperature 33°F) and the cumulus clouds building a few miles offshore. What was unusual were the numerous distinct ímgers of columns of vapor swirling oul of the steam fog layer directly into the over- lying cumulus clouds. It is estimated that they were 50-200 m in diameter, traveled more or less with thc* wind, were ncarly vertical, and showed a slow but distinct rntation «rnostlv cvclonic)

revolutions per minute. The steam devils tended to be rather shuit lived, the longest surviving perhaps for 3 or 4 min, An even more interesting view of the same pbeoo- mena was taken from a commercial airliner on Jan. 30, 1971.....Visible are small cumulus (which were ferming further off- shore on thls day), plus the steam devils and a highly patterned effect on the surface steapn fog. Tt detiniteiy appears that there were quasi-hexagonal eells elongated along the surface wind direction, the largest steam devils beíng present at the vertexes of the hexagons. ”iR3)

X4, December 25, 2000. Gulf of Finland. The Gulf waters were unusually warm, when, on Christmas Day, coid alr (-8 to -10°G) moved in.

"Sea smoke developed as coid air v/as advected over tbe warm sea. From about 0800 to 1300 GMT, steam devils were observen to rise from the seB smoke. Some of the steam devils observed from Helsinki seemed to reach the height of the stratocumulus cloud base at 200250 m. ln Helsinki many of the tallest steam devils were observed in the lee of three small islands, Melkki, Katajaluoto, and Pihlajasaari. These islands are all about 1 km in their longest direction.

"Many steam devils furmed one after another downwind of the islands. They seemed to inove roughly with the mean wind and died 1 to 3 ininutes after their formation." tR4)

References

Rl. Lee, James S.; "A Curious Phenome- non," Scientifíc American. 102:103, 1910. (XI)

R2. "Pillars of Sea Mist May Be Foundation of Myth, " Science News Lettei, 22:84, 1932. (X2)

R3. Lyons, Walter *A.*, and Pease, Steven R.; ’”Steam Devils' over Lake Michigan during a January Arctic Outbreak," Monthly Weather Review, 100:235, 1972. (X3)

R4. Hyvonen, Reijo, and Bister, Marja; "Steam Devils over the Gulf of Fin- land," Weather. 57:51, 2002. (X4)

GWW4 Electrical Properties of Whirlwinds and Dust Devils

Descriptiop. Visual observatíon of electrical díscharges associated with fair-weather dust devils and whirlwinds and instrumented measurements oí their associated electric fields.

Data Evaluation. A few visual observations of overt electrical activity (lightning) comple- mented by data from electric-field meters. Rating: 1.

Anomaly Evaluation. Clouds of airborne particles (dust, snow, etc.) are normally electri- cally charged. It ís therefore not surprising that dust devils and whirlwinds display some electrical properties. The unusual aspeets of this phenomena are the actual production of thunder and lightning under clear skies and the difficull-to-model electric field profiles of passing dust devils. There are, however, no real challenges to prevailing meteorological theories. Rating: 3.

Possible Explanations. The electrical properties of whirlwinds and dust devils merely sig- nify extreme cases oí charge separation in dusty vortexes. Nevertbeless, no readv expla- nation seems to exist for the curious electric-field profiles of dust devils.

Similar and Reiated Phenomena. Electrical phenomena accompanyíng snowstorms and dust- storms (GLD5), electrical properties of tornados (GWT1).

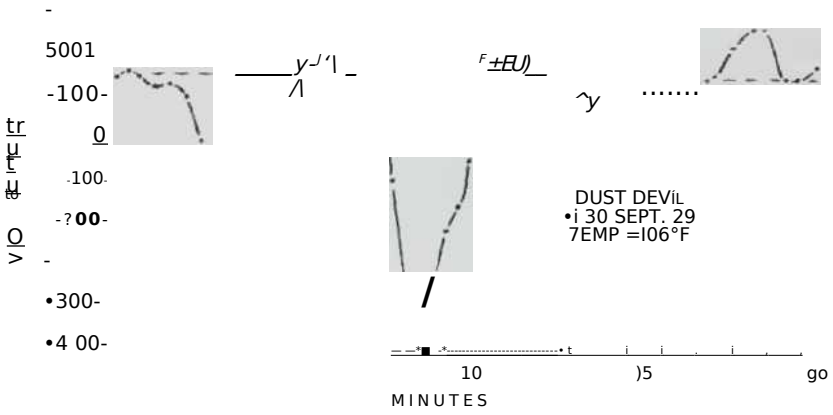
Examples of the Eléctrica! Properties oí Whirlwinds and Dust Devils

XI. 1902. Arizona. "I was on the VVhite Mouatain Apache reservación, in Arizona, on tbe day in question, when an ordinary desert whirlwind whirled into view from ju$t around a southerly projecting point of land nortb of White River from the now aban- doned Fort Apache I had just crossed a fíat area among the hills where an ancient lava flow once spread out, forming a 'lava lake,[1] an area probably six miles across from the afore-mentíoned point to the moun- tainous hills to tbe northwestward, up whicb I was then ascending. In a moment ¡t began to gain momentum on entering the level country and in a minute more it was a roar- ing funnel that was hurling immense quanti- ties of dirt and sand skyward so that they formed an unibrella-llke cloud around the apex of the whirling centet. As the twister was Corning ín my direction, 1 shifted south- ward over a gulch to another rídge to escape its fury On it carne. It entered the canyon in which I had been only a minute before. Here as the canyon both wedged-in and ascended toward the mountains in the direction ít was golng, the rushíng whirl became ’an- gry.' as it were. The day had been períect- ly clear. Yet in a moment there were Chain lightning and ripplng thunder on every side. while at the same time the whirler uprooted trees and tore large-s-ized buulders from their places on the canyon walls, finaily deslroving itself in that the eléctrica! display that aceompanied this whirl was due lo the frictiun caused by the whirling debas." (R1 >

X2. September 29, 1959. Sahara Desert. Experimental observations. "At the time of obtaining measurmnents on the earth's electric Field during an eclipse of the sun in the Sahara Desert at Kidal, French West Africa, an interesting record was oblainfefl on the electric ficld associated with a large dust devil. This record is shown in Figure 1, where positive valúes of the field rnply positivo charge above the earth. The dut t devil was estímated to be between 100 and 200 meters high and about 8 meters ín dia- meter, and its distance of closest approach to the electric field mili was about 30 meters. It was of sufficient strength lo raise anarrny- type sleeping cot severa! meters into the air, and it was followed by truck for about 1 mile beforeit dissipated its energy. Its speed across country was about 4 m/sec.

The two negative excursions with a len- dency to go positive between them suggests a sort of dipole structure for Iht dust devil with negative charge abo\e(inverted thunder- storm). " (R3)

X3. Aueust 21. 1962. Socorro, New México. Experimental observations. Measurements of the electric field of a New México dust devil revealed a structure qual itatively similar to that of X2. Little sucress was had in constructing a model that would account for the electric field structure determined in the field. (R4)



Electric heló oí e passing New Medico dust devit (X3)

XI. General observatíons. "A ptece of metal inserted into a dust devil a few feet aJbove tbe ground becomes strongly charged wlth respect to ground, the amount of eharge and its polariti being apparently a function of the nature of the dust partióles." <R2)

References

Rl. Reagan, AíbertE.; "Sand-Sturm Elec- tricity, " Science, 71:506, 1930. (XI)
R2. Ives, Ronald L. ; "Behavior ol Dust Devils, *' American Meteorológica! Soci- ety, Bulletin, 23:166, 1947. (X4)
R3. Freíer, G. D.; 'The Electric Field oí a Lai'ge Dust Devil," Journal of Geophys- ical Research, 65:3504. 1960. (X2)
R4. Crozier, W. D.; 'The Electric Field of a New México Dust Devil," Journal of Geophysical Research, 69:5427, 1964.

GWW5 Energetic Miniature Vortexes

üescription. l'owerful vortexes measuring just a few feet in diaraeter and perhaps as tall as a person. Many dust devils, whirlwinds, and incipient waterspouts are only a foot or two in diameter and yet display surprising power.

Background. Anyone who spends much time outdoors sees small whirlwinds kicking up lóese leaves and grass. The justification for this entry ís the word "energetic, " which is admit- tedly vague but allows leeway for including a wide variety of small yet unexpeetedly powerful vortexes.

Data Evaluation. Scruliny of hundreds of whirhvind accounts has ytelded only a few examplee of tiny but energetic vortexes. Rating: 3.

Anomaly Evaluation. R is a real puzzle how any accepted meteorológica! mechanism, par- ticularly thermal convection, can concéntrate so much energy in a small vortex. Rating: 2.

Possible Explanations. None.
Similar and Related Phenoniena. AJI rotary disturbances (GWT and GWW).

Examples of Miniature vortexes

XI. Apríl 16, 1372. St. Asaph, England. "On Saturday last, April 16, whilst fishing in the river Elw-ys ai a point about two miles above the well-known Ceñí caves, and five frutn St. Asapb by the river, 1 witnessed a very singular phenomenon. My altention was suddenly ealled up-slreain by a remark- ably strange, hissing, bubbling souud, sucb as might be produced by plunging a massof heated metal into water, ün tunúng I be- held what I may cali a diminutive waterspout in the centre of the stream, Sume forty paces from where I was stamiing. Its base, as well as 1 could observe, was Uttle more than two feet ín diameter.' The water eurled up from the river in an unbroken cylindrical form to a heiglú of about tifteen inches, ro- tating rapidly, then dlyt-tged as from anutn- ber of jets, being thrc-wn off with considerable forcé to an additional elevation of six or seven feet, the spray falling all round as from an elaborately arranged fountain, cov- enog a largo area. It remained apparently Ln the same position for about forty seconds, then moved slowly in the direction of the right bank of the river, and was agaLndrawnn towards the centre, where it remained sla- tionary as befure for a few seconds. As it moved in the former direction, gradually diminishing and losing forcé as ít ne ared the bank, and finally collapsed in the shallow water. Strange to say, it■s course was perpendicular to the bank and not with the cur- rent." (Rl)

X2. July 19. 1913. Hepple, England. “...a narrow strip of wind 1 1/2 ft. wide, drove thruugh a hedge, liíting newly cut hay 60 yards hjgh, proceeded through a tree with great violence, blowing oíí the leaves of a hedge and tree, and upset a haycock in an adjoíning field. It lasted some 10 minutes and was accompanied by great noise. " (R2)

X3. No dale given. Egypt. "Dust-devils, or rotating columna *oí* sand travelling rapidly across upen spaces, are not uncommon ob- jects to desert travellers. Their heightand breadth is often very considerable and the evidence of the eddies causing them very great. The smallest of this type I haveseer, was only about 5 ft. high, that is, the visible eolumn meter lt passt-d so cióse to me that it was easy to see its narrow cyeloidal path marked on the sand, which was deposited and lifted as the eddy travelled on at not less than 15 miles an hour, although the wind was actu- ally very light. " *(R3)*

References

Rl. Gray, J.; "A Waterspout," Nature, 5: 501, 1872. (XI)

R2. Clark, J, Edmund; ”A Narrow Squall," Symons’s Meteorological Magazine, 49: 52, 1914 (X2)

R3. Capíes, J L.; "A Remarkable Whirl- wind." Nature, 135:511, 1935. (X3)

GWW6 Group Organization of Dust and Spray Devils

Description. The appearance of múltiple atmospheric vórtices in well-ordered circles or lines. The vórtices in the circular formations, while spinning on their own axes, aiso usually roíate around the formation's eenter-------a "wheels withm wheels" situotion. The observations on hand nr^{f} not completely forthcoming on the directíons of rotation of the individual vórtices or the circular formations they belong to.

Data Evaluation. The observation of vortex "families” is mostly anecdotal, although their existente seems unquestionable. Data that might be useful to meteorologists (dimensions, directíons of rotation, associated weather conditions. etc.) arr- skimpy. Rating: 3.

Anomaly Evaluation. We have seen no meteorological thecry that explains why geometrically ordered families of vórtices, moving as units, should form and persist. Rating: 3.

Similar and Related Phenomena. The organization of large thunderstorm svstems (GQH3); tornado "outbreaks”).

Entries

XI. Summer 1897. Medicine Lodge, Kan-sas. An observation submitted by U.C Pepoon.

"In the summer of 1897, the exact d«U- is forgottten, at about 3 P.M., I notíced a whirlwind moving from the northwest to the southeast, !t was in every way similar to an ordinary whirl- wind, including the straight wind which necompanied it, exeept that instead of one circular wind five small whirlwinds moved about ᴀ common center. Eoeh whirlwind resembled an ordinary whirl- wind in form and velocitv. They whirled on their individual axes, also on their common axis, to tht right The whirl- winds were about 15 feet high. (RI)

Here, one should imagine a circle of small whirlwinds rotating about a common center.

X2. General observations. An overall look nt India» whirlwinds by P.F íl. Baddeley.

"Dust whirlwinds are common in all parts of India, especian y during the dry season. Sometimos a slender lofty cylindrical pillar of dust is seen revol- ving on its axis of severa! such pillars moving on together in the same direction, or revolving in a circle. or *us* a dense cloud of dust sweeping over the eountry like a tornado, the cloud of dust oc- casionally presenting to the view o dis- tinctly columnar structure. In northern India, the smaller whirlwinds appear in dry, windy weather. They oceur with singular regularity during the míddle of the day. Sometímes a slowly moving whirlwind, instead of appearing as a single column, is found to be composed of several distinct vórtices, each one rotating on its nxií- as it revolves «round in the whiriing circle. Each sepárate vortex has attached to it a fan-shaped train <»f dust." (RI)

X3. General observations from Egypt. R.H. Swinn. formerly Chief Instructor lor the Egyptian Gliding School, has had much practical experience with those fascinating little (sometímes not so little i swjrls of hot air called "dust devils." t'ndcr the broiling Egyptian sun, dust devils launched themselves naturelly ev>tv fe w minutes from a tented camp neor the airfíeld where Swinn taught. Curiously, the devils of- tcn were born in pairs: a big one fol- lowed by a modest litt'<' cliap following behind by 100-150 vards. The devils ranged from just a foot or so iu díamete!- to 500 yards and more. The giants w^re ma jes tic mussos of swirling sand that moved along at leisurely paces.

These appeared harmless enough, but stepping through the outer wall into the vortex suckeri the air out of the lungs.

"Outside our hangar there is a large stretch of wind-sheltered concrete which beeomes intensely hot. In this area, cióse to the foot of the hangar, one can start up one's own little devils on occa- sion by a quick sweep of a signallíng bat (which is shaped like a large ping- pong bat) from shoulder level in circular Bnd downwards direction to a point almost touching the ground; one must step rapidly back or the vortex that is set up is spoilt. Such a miniature thermal starts about a foot in diameter and quickly assumes c cónica! shape about two feet high, loving along the ground at a wulkíng pace. Its rotntion increascs very rapidly, until one has the impression of a whiriing snake in front of one As it reaches the edge of the concrete n little sand is thrown up and the thermal dies away." (R2)

X4. January 30, 2004. Off the coast of Cyprus. When a tornado croases a coast- line and moves out over the water, it beeomes a waterspout. But there is another clnss of weak rotary phenomena of the atmosphere that occurs over the sea. These are the "spray devils."

R. Sanderson spotted three groups of spray devils 1 2 kilometers apart off ttie coast of Cyprus in 2í'04. He wotched one of these groups closely . He wrote to the Journal Weather about this group.

"This group was observed to consist of a ring of spray dt vils about 200 m across, containing four or five devils roughly 100 m in heighi and a few tens of metros across. The individual devils. appearing as pirouetting dancers waving silk scarfs above their heads. were cleor- ly observed to be moving in an anticlock- wise rotation around the periphery of the ring with a pulsating muti. ai both in its own spin and in its speed around the ring, The rotation within ench devil could not be determined due to the spray." (R3)

Th* most interesting featui*c of this group was their ooordinated ruotion. What largor, unseen, rotary phenomenon in the atmosphere was orchestrating this

odd collective circular dance?

X5. 1851. Pakistán. P.F.li. Baddeley noticed a large whirlwind containing smaller whirlwinds within it.

"He observed that some dust devils. instead of appearing as a simple cnlumn. often are composed of several distinct vórtices, each one rotating on its axis as it revolves round and round the vvhirling circle. The English scientist remarked: 'This remarkable sight gives the idea of a fairy dance oround a ring, —and the motions are. from all accounts, exaotly imitated by the dancing Derviches of Turkey.'" (R4)

Xfi. 1902. Statesville, North Carolina. A letter to the Monthly Weather Review described a multivortex dust devü the letter's author had observed.

"He wrote that the dust devil con- sisted of four separóte whirlwinds, which followed each other «round a rircle about twelve feet in diameter, 'like horses going around a hoisepower threshing machine.* The whole dust devil, he saíd, also seemed to be moving to the left around the center of an enlarging coíl." (R4)

References

RI. Anonymous; "Dust Whirls and Fairy Dances," Scientific American Supple- roent, 48:19773, 1899. (XI, X2)

R2. Swinn, R.ll.; "Recipe for Dust Devlls," Journal of ftleteorologv **(U.K.),** T0TÍ7 , 1985. (X 3)

R3. Sanderson, Ray, '"Spray Devils' nenr Paphos, Cyprus, 3U January, 2004," Weather/ 59:168, 2004. (X4; R4. Cerveny, Randv; Freaks of the Storm, Ntw York, 2006, p. 206,

(X5. X6)

GWW7 Sounds of Atmospheric Vórtices

Description. The eurious sounds created by varíous atmospheric vórtices, de- seribed variously as screeehing-howls, flapping, and "swirling" sounds.

Data Evaluation. AL1 reports on file describing vortex sounds are anecdotal. There has, however, been much work done on the dangers aircraft trailing vórtices to other aircraft in landing patterns. Some studies of ground damage are also avail- able. Some of these may mention sound emissions. Rating: 3.

Anomaly Evaluation. That energetic atmospheric vórtices might emit sounds of various sorts is not surprising. Tornados are well-known to roar like on-coming trains, why shouldn't much smaller vórtices whir, screech, and flap" However, it must be admitted that we do not know exactly how such sounds are pro- duced. We, therefore, cataiog them as curiosities. Rating. 3.

Similar and Related Phenomena. Noisy elouds (GWC5); screeching of stratified typhoon waves (GHC3-X1 in Earthquakes, Tides...).

Entry

XI. August 20, 1950. Waldorf, Minnesota. A personal anecdote.

"It was perhaps a roo nd the 20th of August of 1950, and it was harvest time as mv brother and I and our grand- father were busv unloading grain into the elevatoi pouring it inte the granary bin. Fhe day was clear, hot, and muggy, a typical late summer day in Southern Minnesota where ive farmed near the town of Walforí Over the roar of thf elevator and one-cylinder engíne driving it, we sudderdy heard a screeching howl Corning from the southeast. Looking up from our work. wc- were startled to see a solid black, whiriing column about 24" across and extending from the ground perhaps 200 feet, and straight as a power polo. Wben we first heard and snw it, it was coming across the hog pasture toward us in the farmvard across the eountry road separating the hog pasture from the main yard. We wntched in fascination as it whipped up considerable struw from th<~ straw-pile hog shed, moved across the gravel road and crossed the power lines, which whipped in agonized gyrations, then moved across the farmyard where it passed nol more thap 15' from where we were stnnding watching it in awesome fascination. It passed through the grove behind the house where it left a definite cleared area stripped of leaves. üutside of that whiriing and roaring column, there was not a breeze stirring, and it passed not more than 15' away from us." f R1)

X2. General observations. Sounds and ground-effects of aircrall trailing vórtices.

T. Surendonk has written to New Scientist how he and a fríend would stop on Sepulveda Boulevard, at the edge of the Los Angeles airpcrt, to watch the big jets come in directly overhead for a landing.

"While the huge planes were impressive enough, our altention was coptured by an event that someíimes oecuired be- tween twenty and thirty seconds after a plañe had í'lown over a thin tube of misty air would zap past us at apparent iv hígh speed accompanied bjf a rather lnud flapping sound.

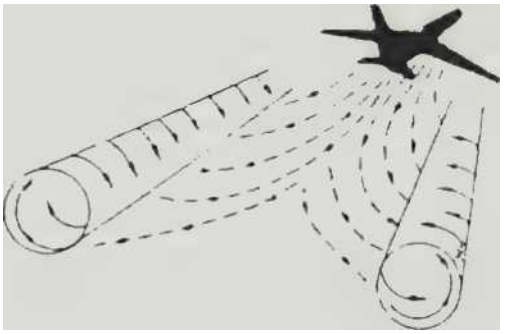
"Sometimos the "mist" would follow a straight path, hut often rt would follow « really contorted path that made 'mis" look like a snake engageri in a rather violen! path---rather cnptivating to watch," (R2)

Another letter on this subject was received by the New Scientist offices from T. Matthewson two vears later.

"llnving lived for inany vears on a hill overlooking Garwick Airport, three miles away as the plañe flies, 1 beenme acccustomed lo the sinister sounds of swirlíng air that would follow aircraft passing overhead-- although visitors walking in the garden would frequently express alarm."

Matthewson also remarked upon how the trailing vórtices young trees in his garden would sometimos be stripped of their upper branches. (R3)

Even ground-level cereal crops have been flattened in circles and other pat- terns by low-flying aircraft. » Rd)



Trailing vórtices created by an aircraft's ***vvt****ng tips. The vórtices roíate in opposite sense****i.*** *(R4)*

References

Rl, Becker, Richard; personal communi- cation, February C, 1983. fXl)
R2. Surendonk, Timothy; "Just Plañe Weird." New Scientist, p 58, March 5, 2994.“tX2)
R3, Matthewson, Tom; "Sinister Swirl- ing." N^w Scientist. p. 56. December 7. 1996. (X2)
R4. Níeaden, G.T.; "A Study of the Effect of Aircraft Trailing Vórtices upon a Cereal- Field near an Airport." Journal of Metcorology (U.K.), 14 9,
TTSH9. |X21

GWW8 Aerodynamic Phenomena as Creators of Simple Crop Circles

Descríption. Neatly flattened circular ureas in cereal fields. Double circles aiid ringed circles are possible, as are a lew other simple configurations. Sízes range frorn a few feet to many yards in extent.

This section does not inciude those elabórate, usually hoaxed, fantastic crop- eircle designs thafháve fuelled the "crop-circle craze," which posiis UFO and/or parapsyehological interventions.

Data Evaluation, Simple crop-circle configurations are rarely mentioned in the seientific and fringe literatura. Daytime-visual observations of simple crop- circle formation are even rarer. Mainstream seientific studies of the phenomenon. as Limited by the above definition, are abserit from our files. Bating: 3.

Anomaiy Evaluation. While whirlwinds and whirlwind-family touchdowns are often blamed for simple crop circles, whirlwinds usually leave obvious trails ol ground disturbances behind them, and these are usually missing in even the simple crop circles. Soroe other atmospheric phenomenon, such as roicrobursts» are aiso possible creators of simple crop circles. This entíre subject lacks seientific attention and, if the simple crop circles are truly of natural origin, ihey are not well-explained. Rating. 3.

Similar and Related Phenomena. All whiriwind and dust-devt) ontries <GWW); microbursts (GWTÍ4).

Eniries

XO. Introduction. "Crop-eircles" is now a general térro applied to an aroazingiy large constellation of circles, other geo-métrica] figures, and often-fantastic designs of flattene-l plants created in cereal fields----roostly by human hoaxers but, in a miuority of cases, probably by atmospheric phenomena, such as whirl-winds .

In the beginning of the crop-circle phenomenon, the crop circles were really just simple circles of flattened grain a few fect to several yards in diameter. Sometimes there were paired circles or even ringed circles, but they were ail "simple." These simple designs are the part of the crop-circle phenomenon that may have natural origins; these are the rrop circles that are of interest in this part of our catalog.

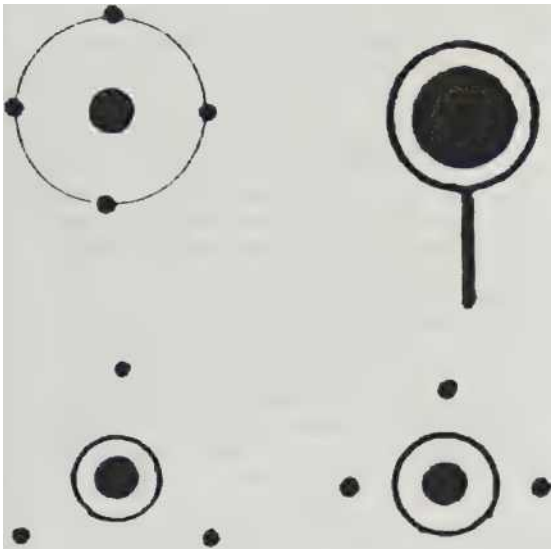
Such simple geométrica] darnage to farmers' fields and, índeed, to wild grasslands has probably been oc-curring for millennia.

The other part of the crop-circle phenomenon consists of those complex figures and designs hyped by news-papers and fringe publicalions. Always, it seems, they are engraved in bucolic fields in the dark of night. They have been associatru with UFOs, extraterres- trials, and sundrv esoteric forres. These are aimost certainlv the works of hoaxers. We relégate them and some similar science-assoeiated lioaxes to a future voluir.e oí this catalog.

We now examine a handful of those "simple" crop circles that probably heve natural origins.

XI. Late Summer 1981, Ross-on-Wye, United Ringdom. Eariy observations linking simple circles inciseri in cereal fields with whirlwinds, as reported by J. lewis.

"1 live on a ridge 450 feet U35 met- res) above sea level, about 100 feet (30 metres) above the adjacent land; it is quite steep in parts on the north side and stretches for about 1} miles (2.5 kilometres). One day, at about noon, I was inside my cottage when suddenly 1 heard a very loud roaring sound, not unlike an express train, I ran outside to see what it was, but saw nothing; the noise was sornething liko the sound of a falling bomb. 1 ihought no more of this until the following morníng when taking



Some "simple" crop-circle palterns (huí are aerodynamically passibíe when ■whirlwinds ond theír satellite whirls louch down in cereal fields.

my dog for a walk. Then 1 saw two large circles, about 25 feet «7,6 metres) in diameter, of flattened barley in a nearby field. A neighbor who Uve? on the north siae of the ridge had siso heard the roaring noise but could iind no cause for it - I wondered if we had heard some part of an aircraft or satellite, or even a small meteor, coming down and, with the local farmer, we investigated the circles, but found no debris at all— just flattened barley. The farmer raid that sometimes growing conditions made barley collapse at its base, though he could not understand the alrnost perfect circle."

Further ¡nvestigation turned up people who had seen a whirlwind in the area at the time. <R1) Also pertinent here is the fact that tornados are often preceded by a roaring sound. So, a stronp whirlwind might produce the noise that was heard by Lewis and others.

Such circles in cereal fields appeared in larg*- numbers in the 1970s and 1980s. They were wiriely publicized.

When alerted to this unusual pheno- menon, UFO enthusiasts quickly attri- buted such circles of flattened crops to UFOs and extraterrestrials. But as lonp; as the crop circles were simple, whirlwinds seemed to be adequate ex- planations for them. In other words, a good observational case was made that some of the crop circles might not be due to rxtraterrestrial activities of to hoaxes (which soon appeared in great numbers).

Incidentally, the noise and aetions of the whirlwind reported above irnpel us to refer the reader to the explosivo onset of some whirlwinds, as described in GWW1.

X2. Circa 1982. Westbury, United King- dom. By this date, UFO enthusiasts had had a fíeld-dav speculating that nighttime landings of alien spacecraft had left be- hind the now-widely-publicized crop circles. However, we do havp a good daytime description of the actual forma- tion of a crop-circle sans UFO The tale is. of course, anécdota! and therefore suspect. In truth, the "waves" described below are rsther curious and suggest that whiríwinds may be aerodynamically more complex than we imagine.

The source is a letter to G.T. IVlea- den, Editor of the Journal of Meteorology (U.K.) from K.A. Barnes.

"1 have been mesning to write to you for some time on the subj^ct of corn circles. About six or seven years ogo 1 was fortúnate tu ser une of these form in a field at Westbury. It happened on a Saturday in earlv July just before six in the evening after a thunderstorm earlier that afternonn, in fact it was still rain- ing slightly,

"My attention was first drawn to n 'wave¹ coming through the heads of the cereal crop in a straight line at steady speedi 1 have since worked this oul to be about fifty miles per hour.

"The ngeney, though invisible, be- haved like a solid objeci throughout and did not show any fluid tendencies; i.e., no vr.riation in speed, line or strerigth. There was no visual aberration either in front. abovo, or below thr advancing line

"After Crossing the field on a shallow are the 'line' dropped to a position about 1 o'clock and radially described a circle 75 ít radius in about 4 seconds. The ageney then disappeared " (R2)

The "wave" observed by Barnes sounds like snmething out of science fiction. He did not compare the "wave" to ¡i whirlwind. All w- h«ve is a superficial description of what is probably an unusual atmospheric phenomenon ol

fome sort—perhaps an unrecognized feature of downbursts (a reeognized meteorológica! phenomenon)- Considering the wave's mysterious inotion, the pre-cisión of the cireles it earved in the field, one would thínk meteorologists would be greatly interested.

Nevertheless, mainstream scientists relegale all crop cireles to the hoax and pseudoscíenee files.

X3. General observations. On one hand, most mainstream scientists, when they deign to notice them at all. pronounce that all crop eircles are the vvork of hoaxers. as is done in the artk ir by J.W. Deardorff referenced below (E3)
On the other hand, several books and o flood ot reporta in fringe publications claiin that the crop tíreles, particularly the complex ones, are evidente that ex-traterrestrial intelligences are attempting to communicate with us.

There is also a middle grourul upon which stands G.'l Meaden, a physicíst, and a í'ew other scientists. Meaden has suinmnrized tlíis third position in the following paragraph using the editorial "we."

[!]...we believe that the formation of reai crop cireles is a rnre phenomenon resultmg from the motion of n spinning rnass of air which Professor Tokio Kikuchi has modelled by Computer simulation and calis a nanoburst. This disturbance could involve the breakdown of an up-spinning vortex of the eddy or whirlwind type.
On this theoretical model such a procoss lecds to plain cireles and ringed cireles — types which are known from pre-hoax times in Britain and other countries, and are the only species which credible eyt-wifnesses have seen forming. All other so-called crop cireles reported in the medra news in recent years are líkely to be the result of intelligent hoaxing, while the so-called paranormal events to which Deardorff alindes are nothing but the consequence of poor observation and/or exaggeration by susceptible mystics and vulnerable pseudoscientists. In the absence of hoaxing the subject would still be unknown to the general public bf>cau*e the average number of real-circle reports per annum is small (indeed in sorae years it may be zero). **(R4)**

In this way, Meaden spiits the crop-circle universe in two (as we have):
(1) Simple cireles and configurations earved out by whirlwinds and other atmospheric phenomena; and (2) Hoax crop cireles which appear in great abun- dance and with elabórate geometries.
They are without any scientific valué, except, perhaps, in psychology! Of course, if some events in this class are not hoaxes. we must reconsider every- thing.

One cannot escape the many parallels between this second crop-circle category and human psychological behavior when confronted with UFOlogy, pyrainidology, remóte viewing, sea monsters, famous assassinations. and the like. In ench area. one finds a cadre of believers. regular publications, International meetings, and a corps of field resear- ebers. Rarely, does mainstream science take notice of observations made by these non-professionals.

X4. General observations relevant to "how crop cireles can be natural and, therefore, legitímate areas of scientific researeh!

Before today's prolific crops of bogus crop cireles, there were raro instanees where Natura nently earved cireles in fields of grain. These legitímate but aneient crop cireles have been trashed by science along with the obvious hoaxes. These oíd observations are still ignored, even though they were reported by eompetent people and published in scientific journals.

A good example of the "real thing" wss resurrected ín the Journal of Metcor- ology (U.K.). The original source is: Nature (certainly no friend of pseudo- scienee) 22:290, 1880. J.R. Capron, a respected spectroscopist ol the time, was the repórter.

"The storms about this part of Surrey have been latelv local and violent, and the effeets produced in some instanees curious. Visiting a neigiibour's farm on Wednesday evening (21st). we íound a field of standing wheat considerably knocked about, not as an entirety, but in patches forming, as vi«*ved from a distance, circular spots.

"Examined more closely, these all presented much the same character; viz., a few standing stalks as a centre, some prostrate stalks with their heads ar- ranged pretty evenly in a direction forming a circle about the centre, and out- side these a circular wall of stalks which had not suffered."

Capron thought the nearly perfect cireles of crop damage bespoke cyclonic

wind dfimagp, (R5)

It seems that whirlwinds may have been carving out crop circles o ver u century ago. lhis uld report ís, oí course, n<> proof of anything. Alt pseudo- Sciences seem to be able to find ancient examples of their beguiling phenomena, such as those Bibiu-al UFOs.

Much as mainstreain scicnce denies what they categorize today as pseudo- science, thp historical record reveáis thnt «orne of thé most reviled scicntific claims (e.g.; continental drift) may one dav achieve scientifíc consensusl Per- hsps, in the futuro, it will be admitted thot a smali proportion of the crop circles—the simpler ones—are natural phenomena.

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GWD1-X2
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GWD1-X4
GWD1-X5
GWD1-X6
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